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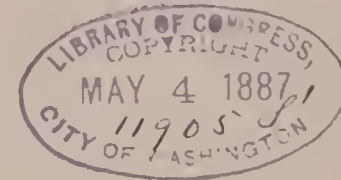
— OF —

MALTER, LIND & ROGERS

ENGINEERS AND CONTRACTORS

SAN FRANCISCO, CAL.

U. S. A.



SPECIAL NOTICE.

We make contracts to furnish and completely erect at the mines, in the United States, Mexico, and other foreign countries, Reduction Works of all descriptions for the treatment of gold, silver, copper or lead ores.

Among the many works we have constructed are the following:

NAME.	MILL.	STAMPS.	LOCATION.	NAME.	MILL.	STAMPS.	LOCATION.
Standard.....	Silver...	20	..Bodie, Cal.	Palmetto.....	Silver...	15	..Colorado.
Noonday.....	Silver...	30	..Bodie, Cal.	Mimbres.....	Silver...	10	..New Mexico.
Bodie Tunnel.....	Silver...	20	..Bodie, Cal.	Carlisle.....	Silver...	20	..New Mexico.
Homestake.....	Gold....	120	..Black Hills, Dakota.	Elkhorn.....	Silver...	10	..Montana.
Plymouth.....	Gold....	40	..Plymouth, Cal.	Gregory.....	Concentration Works.	200 tons.	..Montana.
Valentine.....	Gold....	20	..Amador Co., Cal.	St. Helena.....	Silver...	60	..Sonora, Mexico.
Rainbow.....	Gold....	10	..Sierra Co., Cal.	Tiger.....	Silver...	10	..Arizona.
Contention.....	Silver...	25	..Tombstone, A. T.	Sheep Ranch.....	Gold....	20	..California.
Grand Central.....	Silver...	30	..Tombstone, A. T.	Reilly.....	Silver...	10	..California.
Girard.....	Silver...	20	..Tombstone, A. T.	Silver Queen (Lim.)	Concentration Works.	150 tons.	..Sonora, Mexico.
Head Center.....	Silver...	10	..Tombstone, A. T.	Falcon.....	Silver...	20	..Nevada.
Bradshaw.....	Silver...	10	..Tombstone, A. T.	Alexander.....	Silver...	40	..Nevada.
Silver Cliff.....	Silver...	40	..Colorado.	La Trinidad (Lim.)	Concentration Works.	300 tons.	..Sonora, Mexico.
Game Ridge.....	Silver...	40	..Colorado.	Florence.....	Silver...	20	..Dakota.

 CIRCULAR 

 OF 

MALTER, LIND AND ROGERS.

PREFACE.

We have been engaged for many years in the business of building, furnishing and erecting all descriptions of Mining Machinery in nearly every mineral section of the United States and Mexico. We are thoroughly conversant with the mechanical and metallurgical work of reducing Gold, Silver, Copper and Lead Ores, having learned by widely extended practical operations much that is necessary to insure the best results in the treatment and handling of all classes of free and rebellious Ores—which information could not be acquired except by actual contact with the difficulties met in their profitable reduction under many varying conditions.

This experience will be found to be of great value to our customers in aiding them to guard against wasteful experiments, and in assisting them to obtain the most effective works, at the least possible cost.

We assure our patrons of the most thorough, conscientious and reliable performance of all work intrusted to us.

Respectfully,

MALTER, LIND & ROGERS.

Metallurgical Tests.

The importance of Laboratory Work to the practical Metallurgist is generally under-estimated, for the reason that scientific attainments and practical experience rarely go hand in hand. The chemist can only make his knowledge available by combining it with the practical experience of the metallurgist, and the fact that this has frequently been overlooked, has tended to bring Laboratory Work in experimental Metallurgy, in disrepute.

The first step in all Metallurgical Work is to ascertain the constituents of the ore to be treated and the character of their combination. In some cases a simple assay is sufficient, but in many others a careful analysis is necessary to determine, at least approximately, by what methods the ore can be worked to best advantage—

Then should follow working tests, which the analysis indicates as appropriate, in order to ascertain the best conditions ruling the case in question. Analysis of the products and by-products obtained must be made, and metallurgical experiments, modifying and changing ordinary processes, are frequently rendered necessary by abnormal conditions.

When, after proper investigation, a mode of working is decided upon and the necessary plant has been procured, the work of the laboratory does not cease. Aside from the assays and examinations, which are constantly made in order to control the work done, more intricate investigations are often necessary to find the causes of difficulties presenting themselves, and their proper remedies.

If all work of such character were to be done on a large scale, the cost of it would be enormous, and the losses in experimenting very great. Still this has frequently been done, and many enterprises have failed in consequence of it. A hypothetical case will illustrate these facts more clearly, for example:

An ore containing Silver, Copper and Lead, by careful analysis, proves to contain these metals in combination with sulphur only, with a gangue of silica alumina, lime and

oxides of iron. The proportions of its constituents indicate that the ore could not be profitably roasted and amalgamated or smelted. Concentrating tests prove that the ore may be greatly enriched by concentration, with but little loss and at slight cost.

Smelting tests of the concentrations prove that a Copper Matte, containing all the Silver, is easily obtainable, and these methods, being the most suitable for the reduction of the ore, are accordingly adopted.

All such information can be obtained at a trifling expense, by forwarding a fair average sample of the ore to us, while to carry out any one of the operations mentioned on a large scale would entail great expenditures.

Work of such character can be done thoroughly and reliably at the LABORATORY, by metallurgical chemists of long and extensive experience only, who take into account all conditions under which practical operations on a large scale must be conducted.

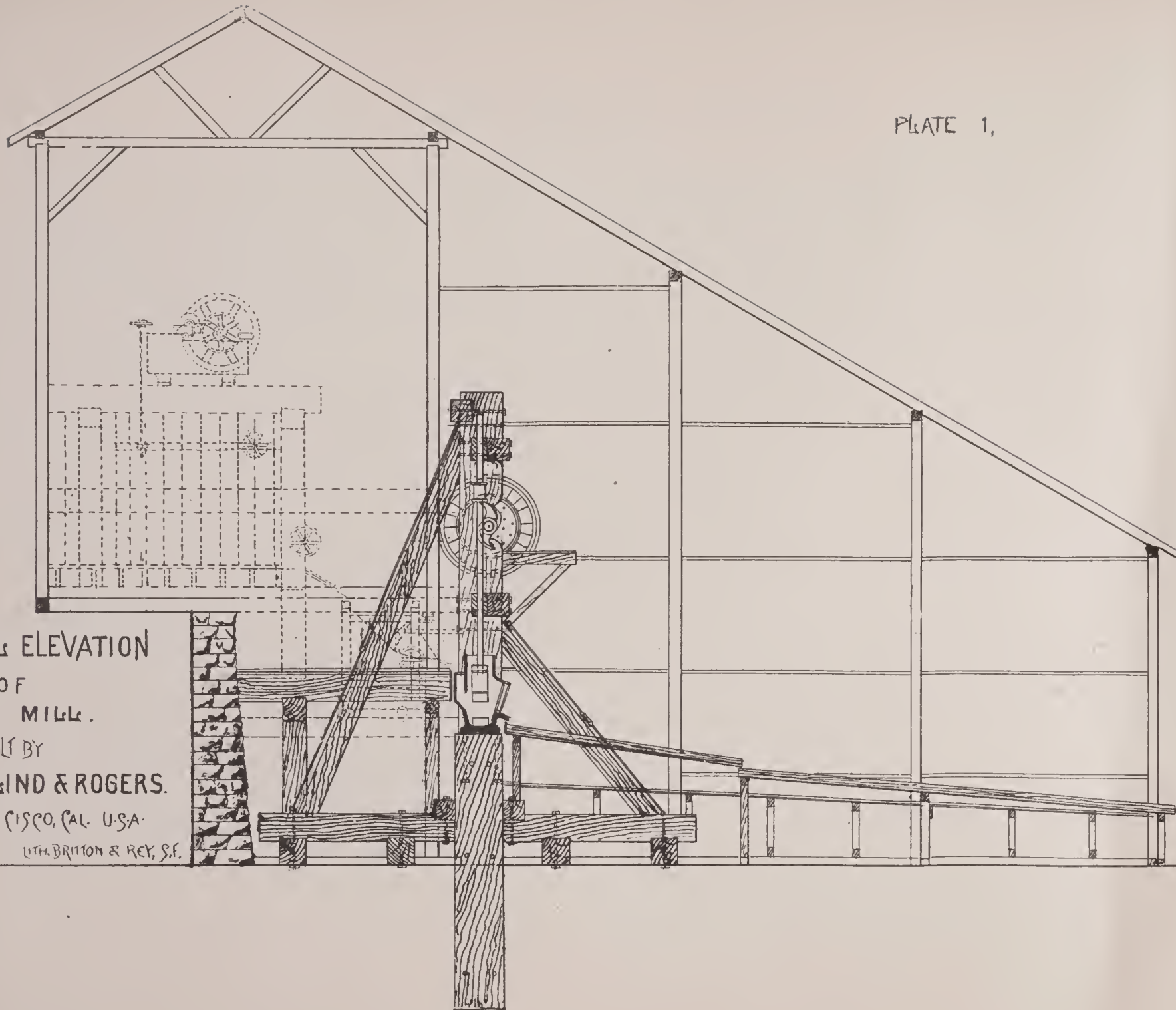
We examine mines and metallurgical works, investigate ores, and give directions for their treatment. If we are intrusted with the preliminary examination of ores, we will have them analyzed and tested by practical working processes, giving customers the benefit of our wide range of experience in determining the most advantageous method of reduction.

For preliminary investigation only a few pounds (average sample) of the ore need be forwarded to us, after which we will be able to fix the quantity needed for a complete examination and working tests. To our patrons we will give full directions for the proper sampling of the ores, concentrations or tailings to secure a fair average. If we are consulted in regard to the method by which ore is to be reduced, and the construction and erection of works intrusted to us, we will guarantee successful results.

We are prepared to give a liberal credit to our patrons, upon fair security.

PLATE 1,

SECTIONAL ELEVATION
OF
GOLD MILL.
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL. U.S.A.
LITH. BRITTON & REY, S.F.



STAMP MILLS FOR THE TREATMENT OF GOLD QUARTZ.

The requisites for good stamp mill machinery are strength, simplicity of construction, and patterns that will give the highest percentage of crushing and amalgamating capacity with the least expenditure of labor and power.

When such machinery has been obtained and placed under the control of intelligent labor, the best results can be expected in the treatment of either gold or silver bearing ores.

Many contrivances have been invented for the purpose of dispensing with the use of stamps in the reduction of ores, but up to the present date nothing has been found to equal them for general and practical every-day work.

Plate No. 1 shows the simplest plan of stamp mill for treating free gold quartz.

The power is furnished by a hurdy gurdy water-wheel, secured to a horizontal shaft, the power from which is transmitted directly by means of pulleys, rubber belts, or hemp or wire rope to the line shaft of the battery.

This mill contains neither rock-breaker nor automatic ore-feeders, and is designed to meet the wants of those whose means are limited, and who, preforce, must use economy in the first outlay. It is, however, so arranged that rock-breaker, ore-bins and feeders can be added at any future date, as shown by the dotted lines, without disturbing the balance of the plant already in place.

This mill being designed for treating only free milling gold ore, is of the simplest possible construction. The gold is liberated from the quartz or gangue by crushing under stamps, and at once amalgamated with the quicksilver in the mortar, without further treatment, the amalgam thus formed being held in the mortar and upon copper sluice-plates outside the mortars until the usual clean-up takes place.

Plate 2 shows a more complete plan of modern stamp mills for the treatment of free gold quartz, containing no valuable sulphurets and hence requiring no concentrating appliances. It illustrates the essential features of the mills which we have constructed for the mines in the Black Hills, Dakota Territory and in California.

This plant contains ore screens, rock breakers, ore bins and automatic feeders and all other necessary appliances for battery reduction and amalgamation; the motive power being obtained by means of a high pressure water-wheel.

The framework of this mill is constructed with special view to give it strength and durability. The mill contains all convenient appliances for cheaply handling the ores and operating the works.

Plate No. 3 shows another and similar design of stamp mill, with concentrators.

This mill is designed to treat ores containing gold bearing sulphurets, of the character most commonly found in California. It has all of the useful appliances for a first-class plant of this kind, including ore screens, rock breakers, automatic feeders, batteries, copper-plated sluices and concentrators, using either steam or water as the motive power.

In the separation of gold bearing sulphurets from the tailings of stamp mills, it is not generally thought necessary to size the ores for concentration, and, therefore, the process in use is quite simple, the machines employed being usually of the endless belt or shaking table patterns, shown in the plan.

Plate No. 4 illustrates a stamp mill with pan amalgamation suitable for gold ores, from which the precious metals cannot be extracted by the ordinary mortar amalgamation, for the reason that it does not permit of heating the mercury and water used. Only the purest gold can be dissolved in cold mercury; gold containing traces of silver or other metals, will not readily amalgamate in cold mercury. For this reason, battery amalgamation is at best an inefficient process in many cases, causing much loss of valuable metal, particularly in the working of clayey ores, in which, the gold is finely divided and not altogether free as is usually the case.

Battery amalgamation is successful only in working clean quartz ores, containing pure and coarse gold, the finer gold is easily carried away from the mortars and copper plates by the currents of water, and low grade gold will not adhere to the amalgamated copper plates.

Many financial failures have resulted in working valuable mines for the reason that battery amalgamation has been attempted upon ores which should have been subjected to the more effective treatment in pans.

The ores from many mines which are being worked in a measure successfully, do not yield more than 50 or 60 per cent of the valuable metal by the battery process of amalgamation. With but few exceptions, much more satisfactory results could be obtained by subjecting gold ores to a pan amalgamation process similar in manner to that in which silver ores are treated.

The first cost of such a plant is somewhat greater than that of the ordinary gold mills, but the increased percentage of reduction per stamp and actual saving in precious metal which can be effected, will soon repay any additional outlay in first cost.

Plate No. 5 shows a mill for the reduction of gold ores of a more complex nature. The gold, which although free from union with refractory metals, being in alloy with some silver, will not readily amalgamate with cold mercury hence requires pan amalgamation, differing, however, in the construction of pans used.

The sulphurets being valuable and of such a nature as to resist and interfere with the amalgamation of the gold in pans requires previous separation by means of concentrating machines.

The ores are brought from the mines to mill by means of wire rope tramways.

In this mill, the battery serves solely for the purpose of crushing the ores; the amalgamation is altogether effected in the pans, after the gold bearing sulphurets have been separated by means of the concentrating machines placed between the battery and pans. The settlers in this plant operate the same as in silver mills to settle and separate the amalgam from the pan tailings.

Plate No. 6 shows ground plan of the mill shown in plate 5.

Design No. 7 illustrates the general character of continuous working gold mills, using our patent grinding mill in connection with the battery.

Ore can be more cheaply reduced to a certain degree of fineness in a stamp battery than by any other means, but after having reached that degree of fineness, it is more easily ground. The use of an arrastra largely increases the crushing capacity of the battery mill, especially with ores in which the metal is finely divided, and which, therefore, requires to be reduced to a very fine state to permit the extraction of the gold.

The ore, after passing the crushers, is handled entirely by automatic machines.

SECTIONAL SIDE ELEVATION
OF A
60 STAMP GOLD QUARTZ MILL,
WITH
BATTERY AMALGAMATION.

PLATE 2.

BUILT BY, MALTER, WIND & ROGERS.

SAN FRANCISCO, CAL.

U.S.A.

LITH. CHITON & REY, S.F.

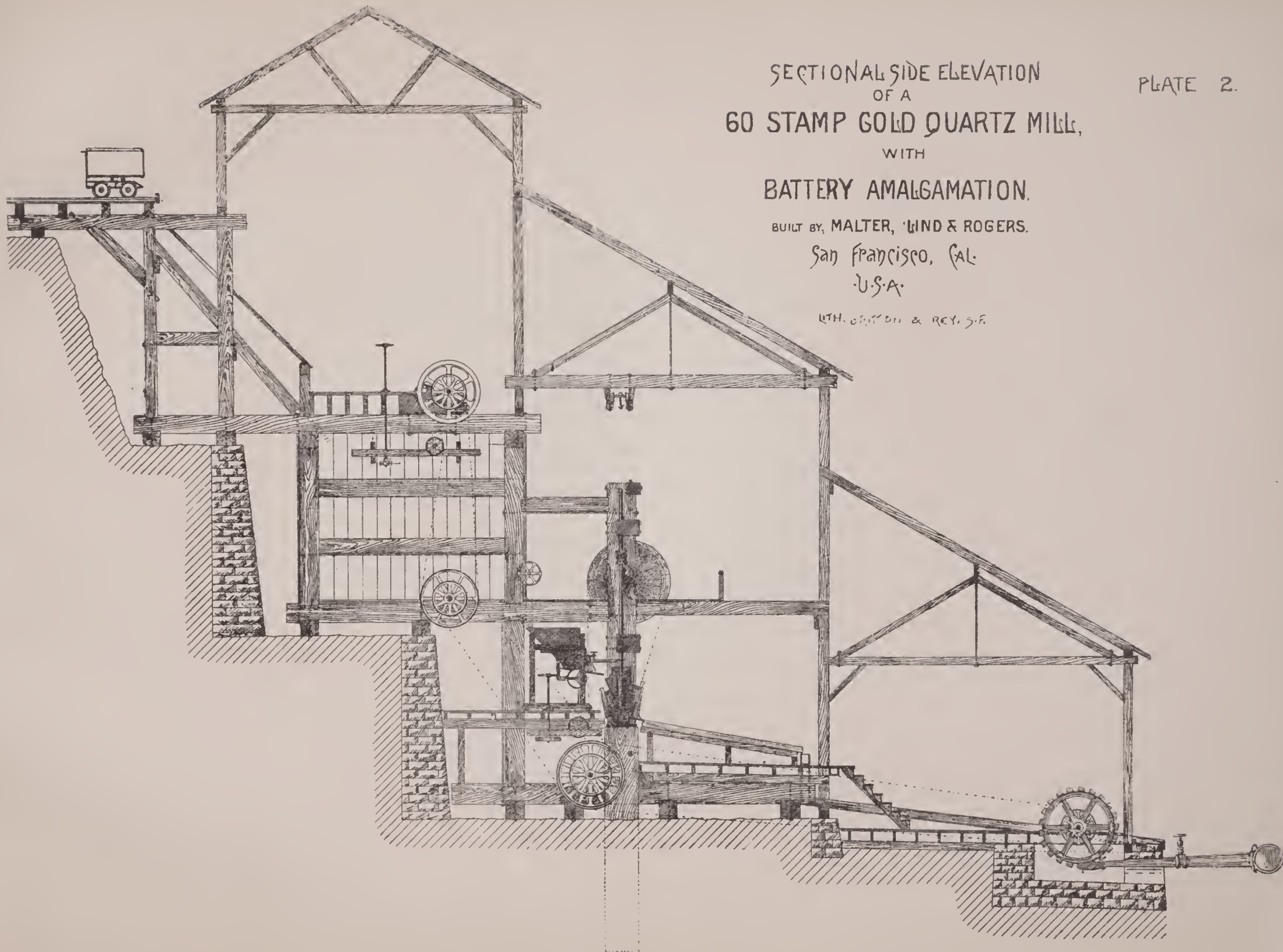


Plate No. 8 shows sectional side elevation of one hundred and twenty stamp gold mill which we furnished and built for the Homestake Mining Company at the Black Hills, Dakota Territory.

The ore bins are placed between the batteries which are thus arranged back to back.

The ore is delivered to this mill by means of narrow gauge locomotive and cars not shown in the drawing.

Plate No. 9 illustrates the same general character of mill the ore bin floors are flat instead of being placed at an incline as shown in plate 8.

SILVER MILLS.

Silver mills may be classed under two heads:

1st.—The wet crushing and raw amalgamating mills.

2d.—The dry crushing and chloridizing mills.

The first structures are less complicated, less costly, and by them the ores can be treated more cheaply than by dry crushing and roasting, but are of service only in working those free ores which contain the precious metals in the form of chlorides.

In the second class of mills, ores containing silver in any state may be worked, provided there be not too much base metal in connection with the silver.

WET CRUSHING MILLS.

In wet crushing mills, the pulp is deposited either in wooden settling tanks, shown on plans, or directly in grinding pans as in the continuous process elsewhere described.

In the settling tanks, the pulp carrying the metals, gradually sinks to the bottom, while the water used in the battery to facilitate crushing, is partially carried away by means of sluices arranged for that purpose, or is pumped back, to be used again in the battery for the purpose of economizing water, and also for the purpose of saving the very fine and valuable metals floating in the water. From the tanks, the pulp is shovelled or pumped into the grinding pans, where quicksilver and chemicals are added, and the further grinding and treatment proceeded with: in this process, the friction of iron surfaces, in contact, are strong agents in the decomposition of the sulphurets of silver.

Many combinations of chemicals depending upon the character of the ores under treatment, have been used—some useful and others useless; among the most common are salt, sulphate of copper (blue vitriol), sulphuric acid and sulphate of iron—also cyanide of potassium, etc.

Wet crushing silver mills, may again be classed under two heads: 1st.—Those which *work in charges*, and 2d, those which *work continuously*.

Design No. 10 shows one of our plans for the construction of a wet crushing silver mill of the first description, as most commonly used in it, all of the convenient accessories are provided to save labor as much as possible.

The ores are first introduced into the mill in the ore-house, shown at the top of the drawing—to the left—dumped over ore-screens, made of iron bars, into the receiving ore-bins beneath, while the coarser passes on to the rock-breaker floor, where it is crushed finer, by crushers provided for that purpose, and then also falls into the bins beneath, from which it is conducted by chutes to the automatic ore feeders which supply the stamps as required.

Each mortar has sheet iron or wire screens, more or less fine, through which the crushed pulp escapes and is then conducted to the settling tanks or pans as the case may be, where the grinding and amalgamation is completed; from the pans, the pulp is discharged into the settlers and thinned by the addition of water to settle the amalgam, which is then drawn off to be retorted and melted into bars for shipment.

The time required for reducing a given quantity of ore, depends largely upon the design of the crushers, mortars and pans, as also upon the character of ore under treatment.

In the *continuous* plan, the pulp charged into one or more pans, makes a continuous circuit of several pans and settlers, before it is drawn off; should the amalgamation begin in one pan, and not finish there, it continues in the next and so on until it is completed. These mills are especially adapted for low grade ores, in which all possible expense of handling must be avoided.

Plate No. 11 shows the ground plan of a twenty stamp continuous working silver mill, with Lind battery frames. In this plan, only six of our patent pans and two settlers are required for twenty stamps. The pulp from the settlers is sized by means of the hydraulic separators, before it is concentrated upon the tables.

Silver ores, unlike gold-bearing pyrites, are not so readily concentrated, and require to be sized before treatment on tables, as the specific gravity of silver ores is not so great as that of gold ores.

Design No. 12 illustrates a continuous working wet crushing silver mill for soft and decomposed ores, in which plan, the battery is replaced by our patent arrastra grinding mill.

The ore is prepared for the arrastras by means of coarse and fine crushers, as shown in the design.

DRY CRUSHING AND ROASTING SILVER MILLS.

In the process of treating the so-called rebellious silver ores, containing sulphur, antimony, arsenic, lead, copper, etc., in combination, a chloridizing roasting, with salt, is first employed, before amalgamation can be successfully accomplished in pans.

In this process, the ore coming from the mine is first dried by heat, either on platform or in mechanical dryers elsewhere described, before being introduced into the stamp battery. After drying, the ore is discharged into bins or ore feeders, from which it is fed to the stamps, crushed dry until sufficiently pulverized to be discharged through fine wire screens into conveyors which carry it to the elevators; they in turn elevate it to the bins located near the roasting furnaces, from which it is fed into furnaces where the roasting is effected.

The salt is sometimes crushed in the batteries with the ores, but more frequently in separate crushers or batteries, for the reason that salt is a substance which easily absorbs moisture, forming a paste with the ore which is apt to clog the screens. The proper percentage of salt is fed with the pulverized ore into the roasting furnace, after the roasting process is completed; the pulp is discharged on cooling floors and from there transported to the pans in cars provided for that purpose.

The after treatment in the pans, is similar to that used in the wet process, only that little or no grinding is done.

In this process, the roasting is a very important feature, and upon it depends largely the after success in amalgamation.

There are several patent furnaces in successful use: the Stedefelt, Bruckner, White, White & Howell, Dodge and O'Harra, all are useful under different conditions.

Where the ores are to be roasted in charges, the Bruckner furnaces are generally used, but the White, Dodge or Stedefelt patents are preferable where the ores do not require long continued roasting.

Design No. 13 shows the side elevation of a 20-stamp dry crushing and roasting silver mill, having rock-breaker, revolving dryer, ore feeders, batteries, conveyors, revolving roasting furnaces, pans and settlers, with the latest improvements in all details affecting the working of the mill.

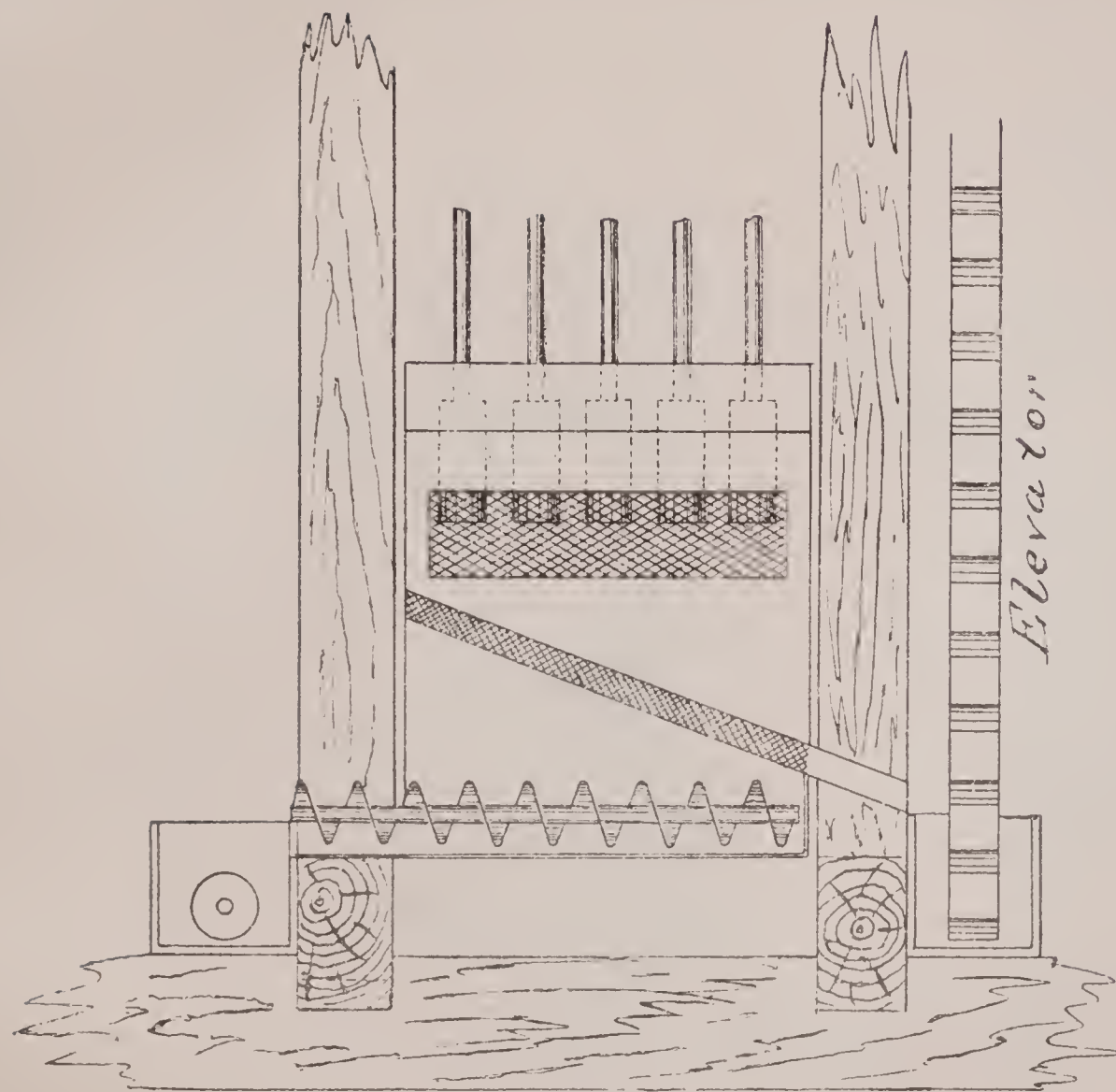
Design No. 14 shows ground plan of a similar mill.

IMPROVEMENT IN DRY CRUSHING.

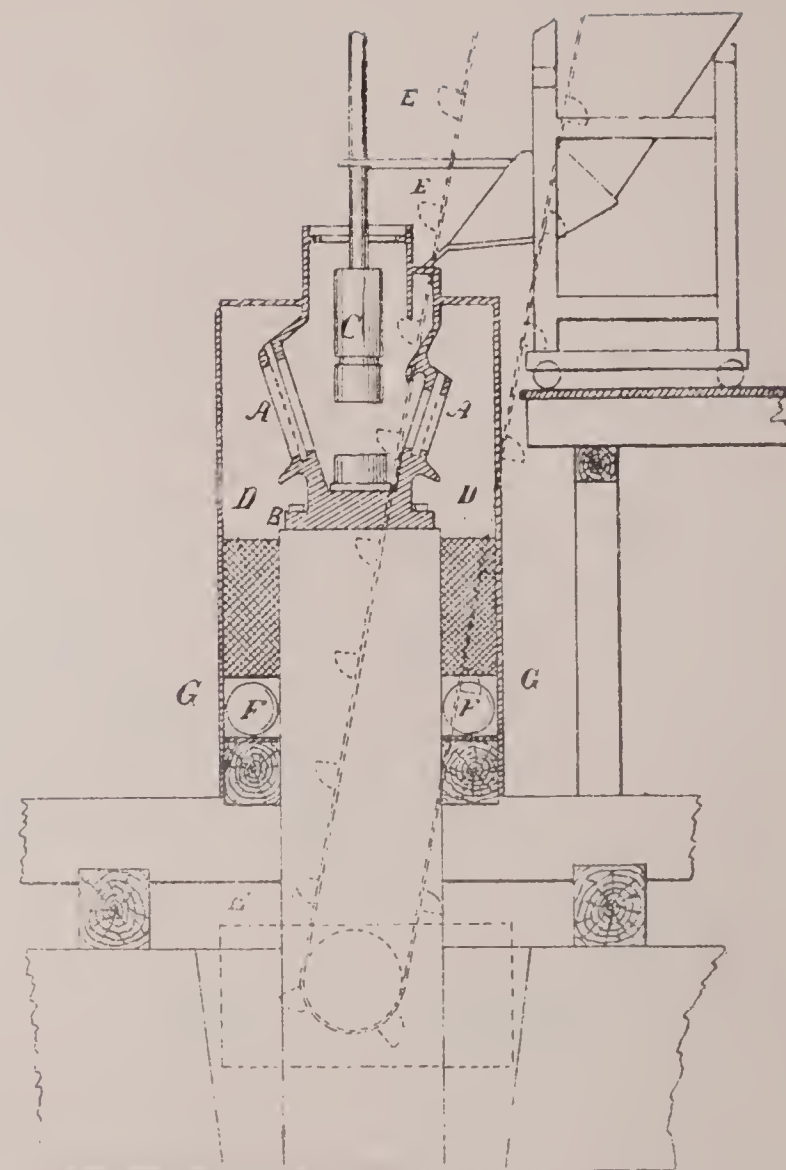
Dry crushing batteries, as usually constructed, do not give more than 60 per cent of the work done by a wet crushing battery.

The crushing capacity of the battery can be greatly increased however, by using our patent re-screening device, in which two sets of screens are used. The first screens somewhat coarser than the ore required for subsequent working are placed in the sides of mortar and the second screens just fine enough for the ore are placed outside of the mortar beneath and directly in front of the others. By this arrangement the crushed ore is more readily discharged from the mortar and the stamps do not expend useless force in continuing to hammer upon it after being sufficiently fine. Unnecessary pounding and shining of the ore is thereby avoided, the crushing capacity of the stamps largely increased and the loss from float dust and sluice are greatly diminished in the subsequent working it before it is discharged through the screens. The great importance of this can only be appreciated by mill men who have had experience in working ores by the dry process.

Cuts No. 1-2 show a sectional view of dry crushing battery fitted with our patent rescreening device, in which (C) is a stamp working in the cast iron mortar (B). (A) represents the battery screens, which in this arrangement are much coarser than those usually employed for dry crushing. (D) is a fine screen set at an angle with the mortar; upon it the powdered ore falls as it comes through the screens (A). That which is fine enough then passes through the screen (D) to conveyors (F) which take it to the elevator feeding the roasting furnaces; that which is too coarse to pass the screen (D) passes over it to the elevator (E), and by it is returned to the mortar to be recrushed.



Cut 1.



Cut 2.—Standard patent rescreening Battery for Dry Crushing Stamps.

STAMP BATTERY.

A stamp battery consists of the following parts :

Mortar, cam-shaft, driving pulley, cams, bearing boxes, stems, stem shoe and die, stamp heads, tappets, guides and the battery frame.

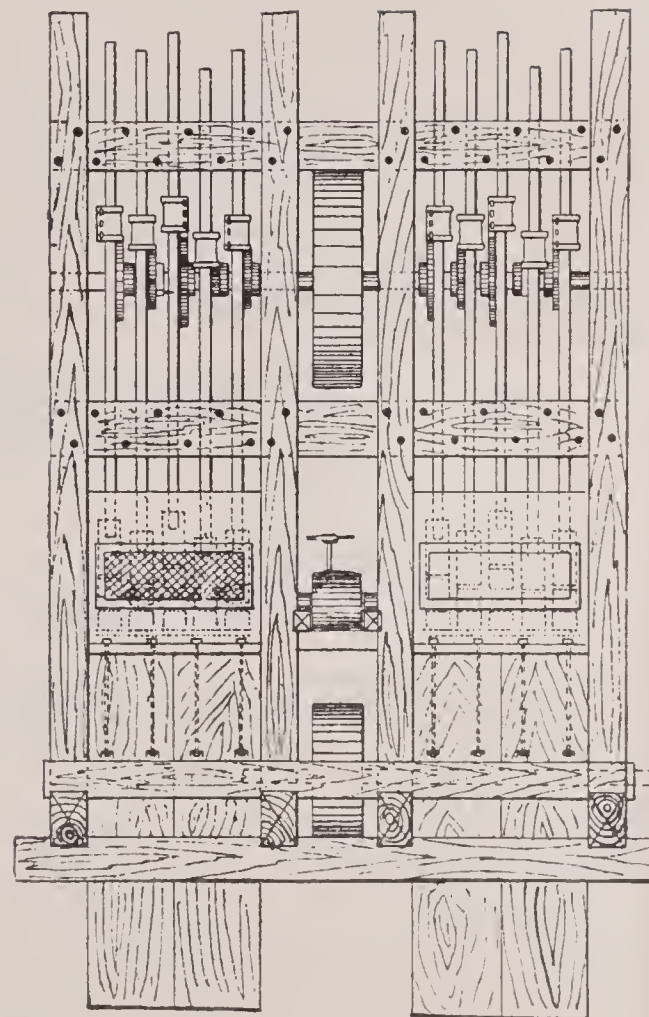
BATTERY FRAME.

The battery frame is usually built of heavy timber ; iron frames are not any longer in use, they do not well serve the purpose ; it is practically almost impossible to construct them in such a manner as to withstand the wear and tear consequent to the great jar of the stamp.

The mortars are set upon heavy wooden blocks, standing upon end and being from twelve to sixteen feet in length. These so-called mortar blocks are not rigidly attached to the battery frame proper, which carries the shafting, in order to avoid the transmission of the jar of the stamp to the machinery.

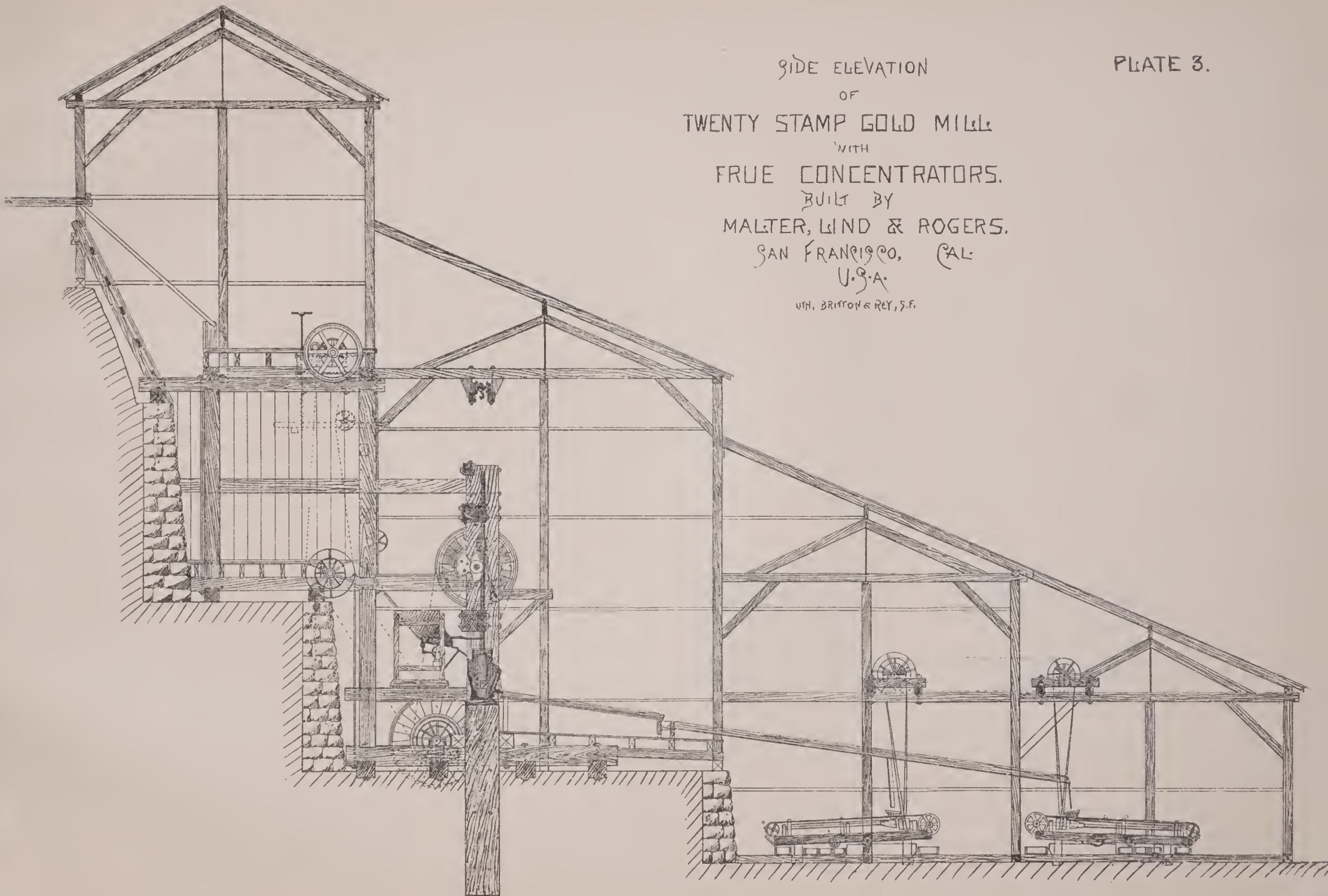
Battery frames are not generally made to receive more than 10 stamps. In large mills, a number of separate frames, each carrying 10 stamps are placed side by side. Ordinarily, each frame for 10 stamps has three posts with the necessary sills and braces. In mills having 20 stamps or more, two 10 stamp batteries are sometimes connected so as to make one post support the ends of both cam-shafts. This center post is then made of heavier timber. A battery so constructed is shown on plate 5 the driving pulley is secured to the end of the cam-shaft and overhangs its bearing.

The accompanying plate shows a front elevation of a 10 stamp battery frame, of our improved construction, having four posts—the driving pulley is keyed to center of cam-shaft—a bearing box is placed on each side of it.



SIDE ELEVATION
OF
TWENTY STAMP GOLD MILL
WITH
FRUE CONCENTRATORS.
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL.
U.S.A.
W.H. BRITTON & REY, S.F.

PLATE 3.



MORTARS.

The mortar is the most important part of a battery. Upon its proper construction depends very largely the efficiency of the battery in its crushing capacity or as an amalgamating apparatus if so used, as is frequently done in gold mills. If the screens are given too much or too little inclination, the crushed ore either does not readily sieve through them, or it lodges upon them; if they are set too high or too low, they either permit too much ore to lie upon the die, retarding the efficiency of the stamp, or they are exposed to too frequent breakage, by large lumps of ore being violently thrown against them by the fall of the stamp.

For light ores, the screens must be set nearer upright, for heavy ores they should be more inclined.

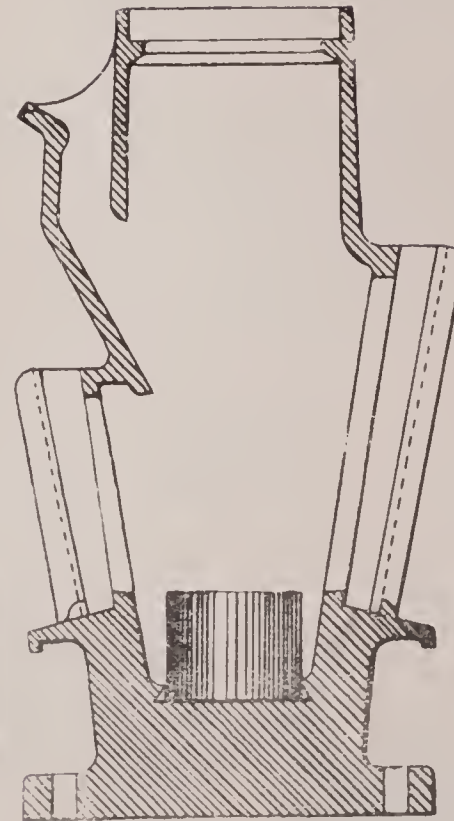
The less favorable the positions of the screens, the more of the ore is hammered into an impalpable dust, which often causes loss in subsequent operations by floating off as in roasting or amalgamating.

It has become the almost unexceptional practice to make mortars to receive five stamps.

Cuts 4 and 5 show sectional views of two ordinary double discharge mortars, as used for dry crushing stamps. The bottom of mortar is from 6 to 7 inches thick.

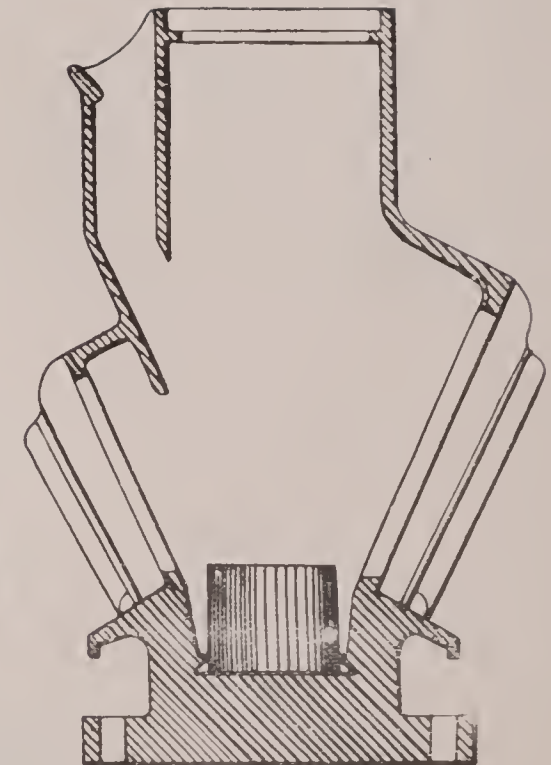
The dies are secured in their places by means of taper projections.

The principal difference between these mortars is the degree of inclination at which their screens are set.



Cut 4.

Mortar for
Dry Crushing.



Cut 5.

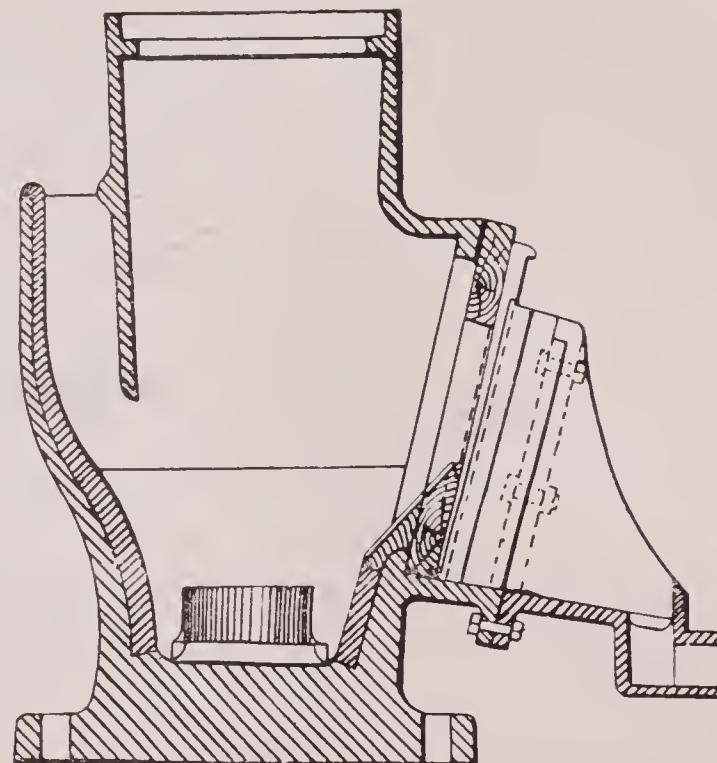
Mortar for
Dry Crushing.

Cut 6 shows a single discharge gold mortar, as used in many mills in California, in which the amalgamation is principally effected in the mortar. A narrow strip of silver-plated copper is attached to the lower bar of the screen frame, in an inclined position, so that the "swash" of the ore pulp in passing towards and through the screen may deposit the gold upon it.

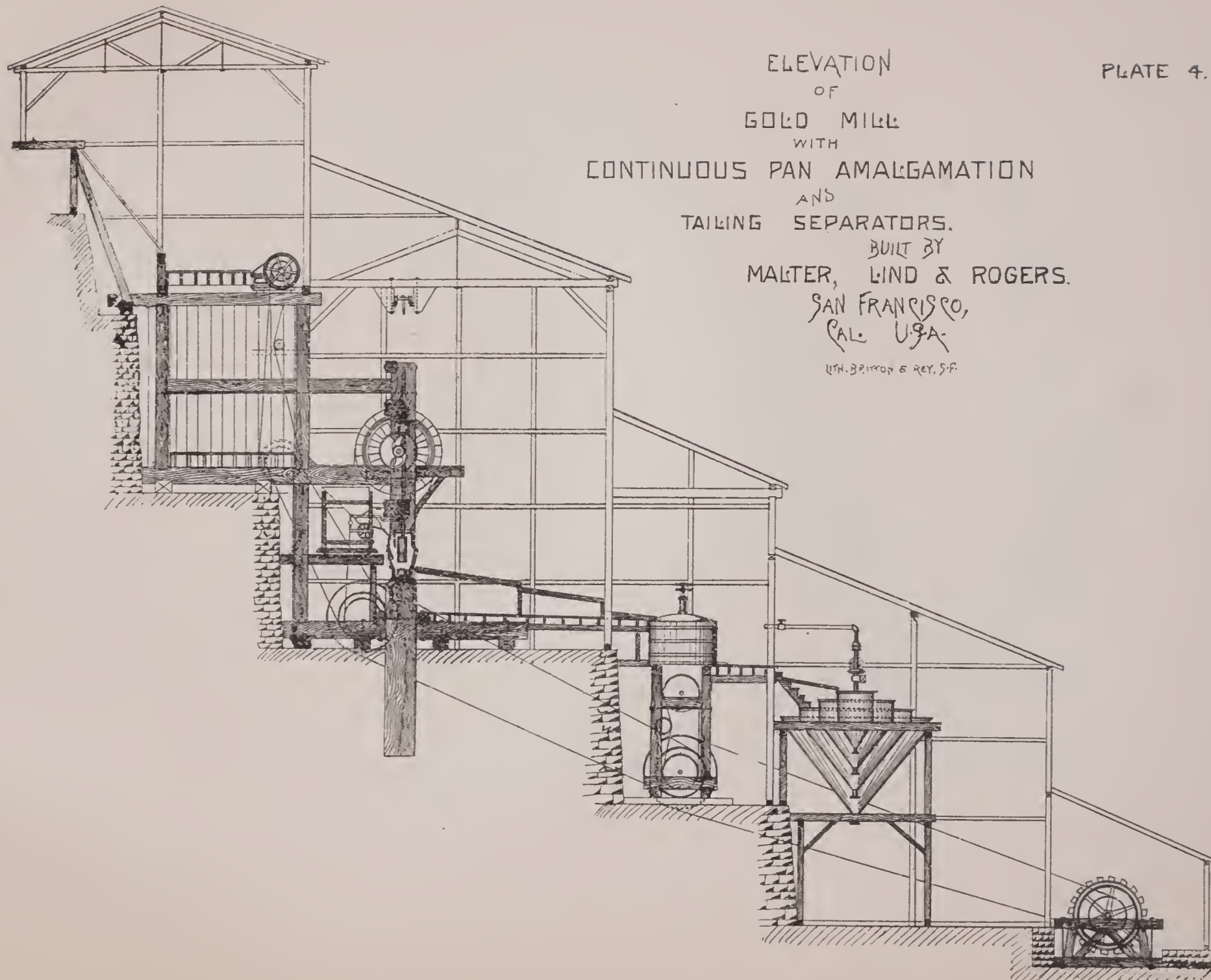
The sides of the mortar are lined with a thick cast or wrought iron plate which may be replaced as it wears out.

A cast iron apron, having a spout on one end, is bolted to the front of mortar for the purpose of carrying the discharged sands away into the sluices.

The screen frame is secured in the ordinary manner by means of wrought iron keys.



Cut 6.—Gold Mortar.



ELEVATION
OF
GOLD MILL
WITH
CONTINUOUS PAN AMALGAMATION
AND
TAILING SEPARATORS.

BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO,
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LITH. BRITTON & REY, S.F.

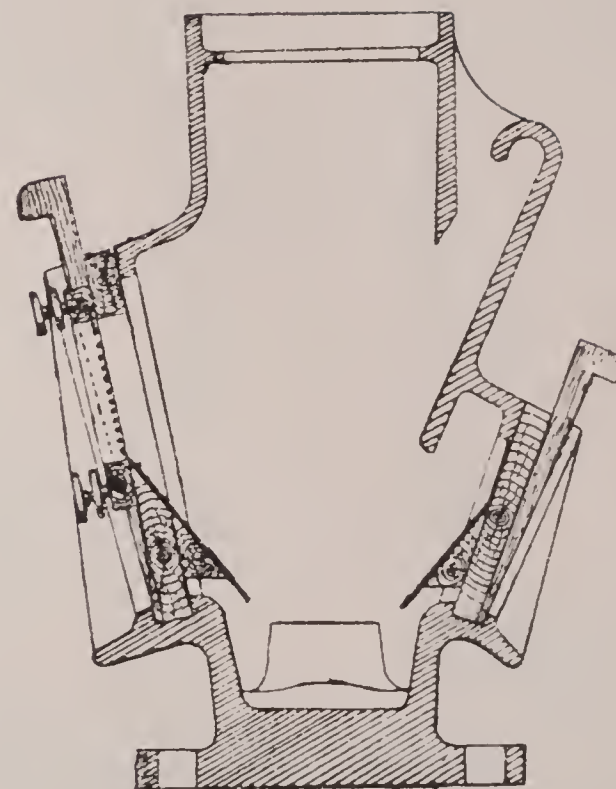
PLATE 4.

Cut 7 shows an amalgamating gold mortar, as used both east and west of the Rocky Mountains. It differs from the former mortar principally in having an amalgamated copper plate secured to both its front and back. The front plate is, usually, attached to the screen frame. The back plate is fastened to a plank which covers an opening, and is secured in its place like the screen frame, by means of keys. In order to give these screens the most advantageous inclination for the purpose of amalgamation, so that the sands will neither lodge upon them, nor glide too rapidly over them, wooden wedge blocks are secured to both the lower bars of the screen frame and the plank in rear, as is shown in the cut.

As the dies wear down in the mortar it becomes necessary to lower both the amalgamated copper plates by setting down the screen frame and the rear plank so as to keep uniform the distance between the lower edge of plate and the top of dies.

The screen is not attached directly to the screen frame, so-called, which carries the amalgamating plate on its lower bar, but it is secured to a smaller frame, a screen frame proper, which is fastened to the larger frame by means of heavy thumb screws and check nuts.

The arrangement makes the removal of the screen possible without lifting out the heavy frame and disturbing the copper plate.

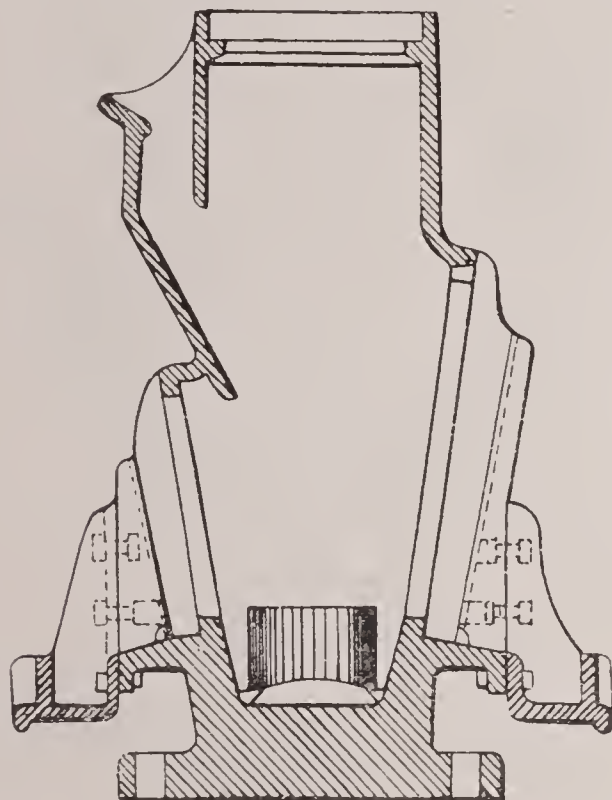


Cut 4.

Mortar with Copper Plates for Crushing and Amalgamating Gold Ores.

Cut 8 represents a double discharge wet crushing mortar, as used in silver mills. It has discharge aprons attached to both its sides. Single discharge wet crushing mortars are more frequently used than those having double discharge.

The crushing capacity of the wet crushing mortar, unlike the dry crushing mortar, is not very materially increased by giving it two discharge openings instead of one.



Cut 8.—Double discharge Wet Crushing Mortar.

SIDE ELEVATION OF A

40 STAMP GOLD MILL,

PLATE 5.

WITH

BATTERY AND PAN AMALGAMATION

AND

TRIUMPH CONCENTRATORS.

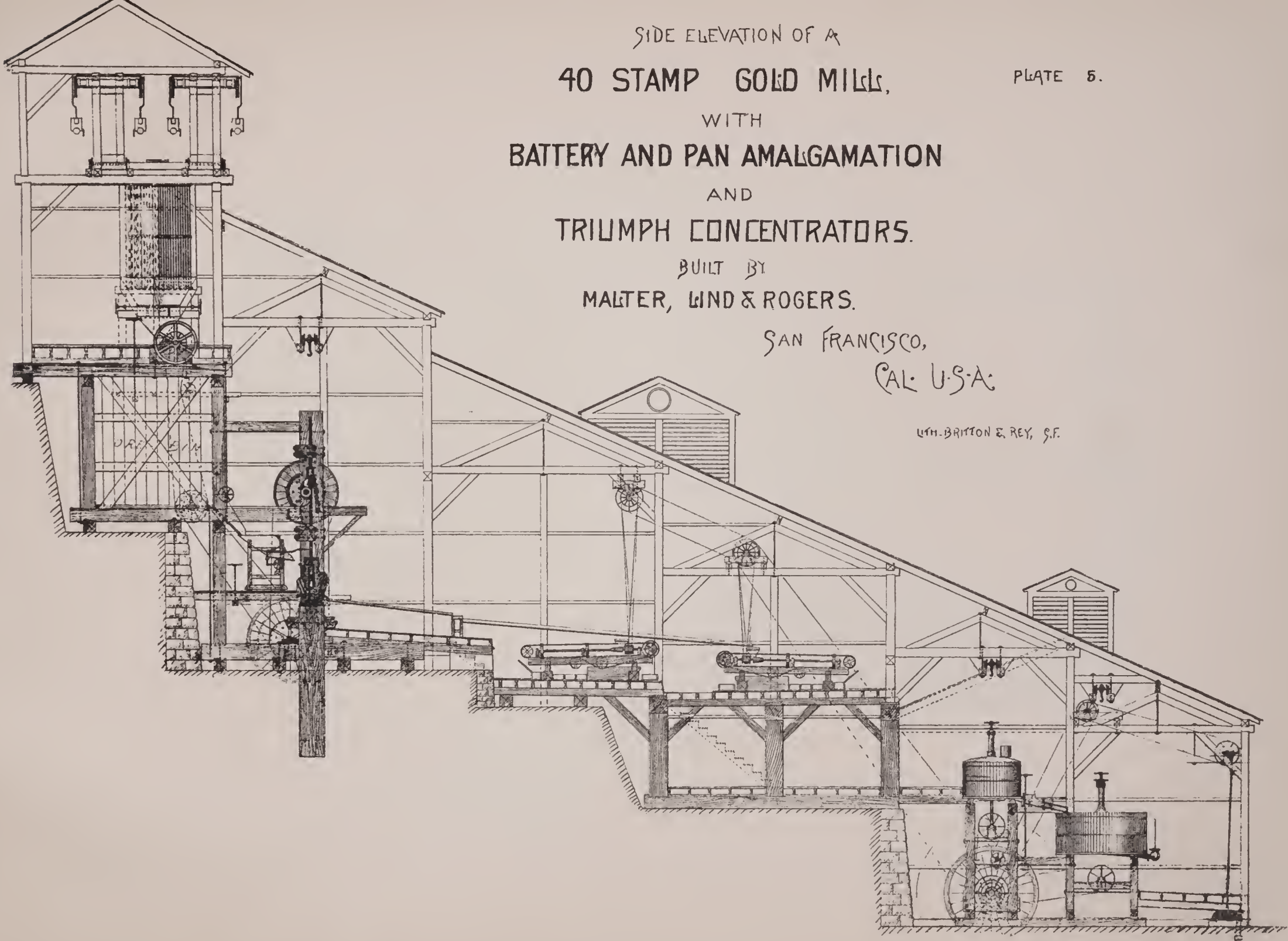
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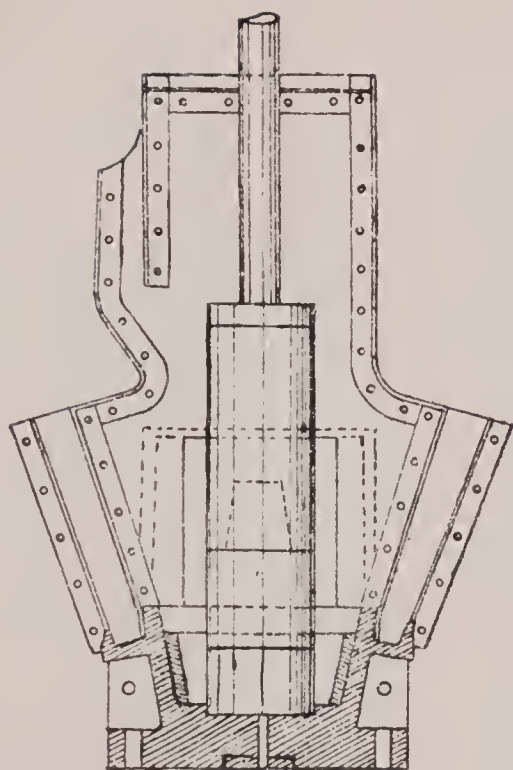
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CAL. U.S.A.

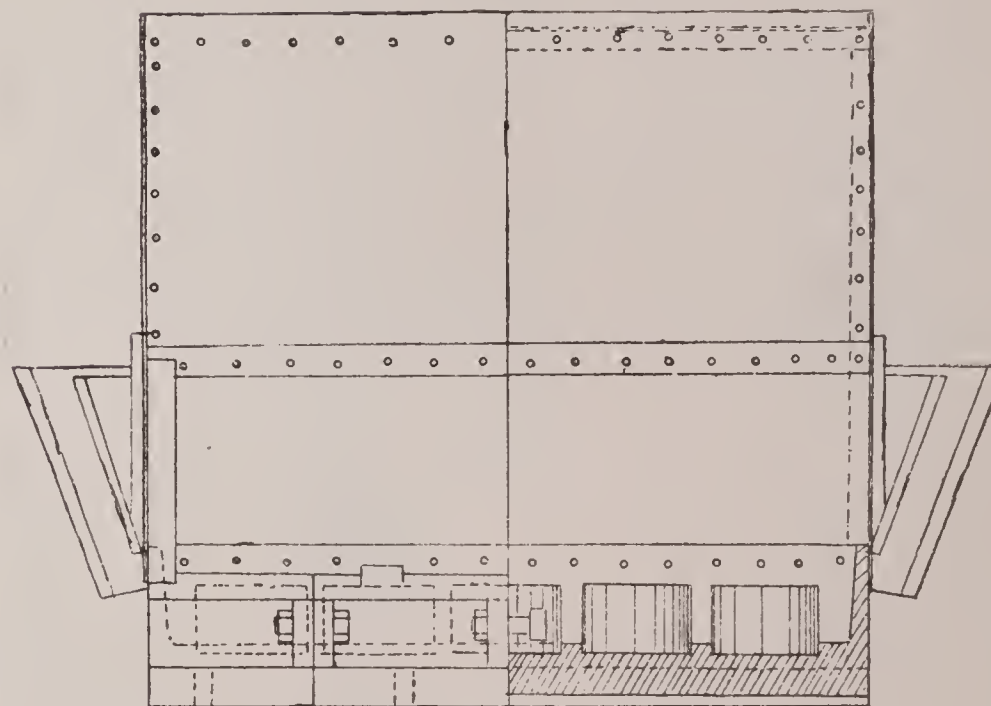
LITH. BRITTON & REY, S.F.





Cut 9

Cuts 9 and 10 show a sectional mortar, designed for transportation on mule back, into distant mining regions to which no wagon roads lead. The sections are made to weigh not more than 300 pounds, and are planed, fitted and bolted with reamed bolts or riveted together.



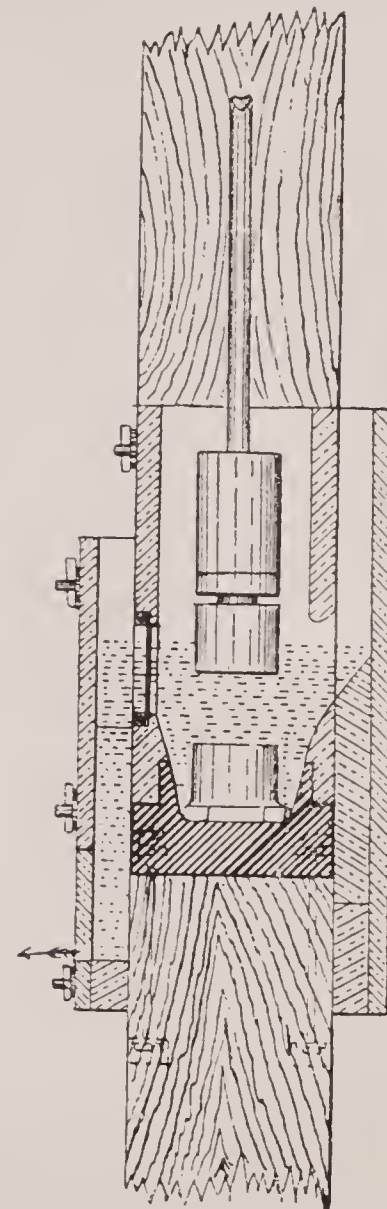
Cut 10.—Dry Crushing Mortar.

Made in Sections.

This Mortar is intended for a dry crushing battery and has four screen openings. The upper part of mortar is made of boiler plate, the bottom of cast iron.

Cut 11 shows the simplest and cheapest construction of a mortar, as sometimes used in distant mining regions. The base of mortar alone, is made of cast iron; the top is constructed of wood and securely bolted to base and mortar block. Unlike the other mortars, this construction of mortar has a water box outside of the screen, submerging the screen entirely in water. The purpose of this arrangement is to avoid the clogging of the screen by particles of ore which always takes place in some degree when the water flows continuously from inside of mortar toward the outside. If the water be held outside of the screen at the same level with that inside of the mortar, as shown in the above cut, a back splash results, which effectively clears the screen.

This arrangement is of service when it is very desirable to avoid making slimes, as is usually the case with ores which are being crushed for purpose of concentration.



Cut 11.—Sectional view of Mortar, with wooden top.

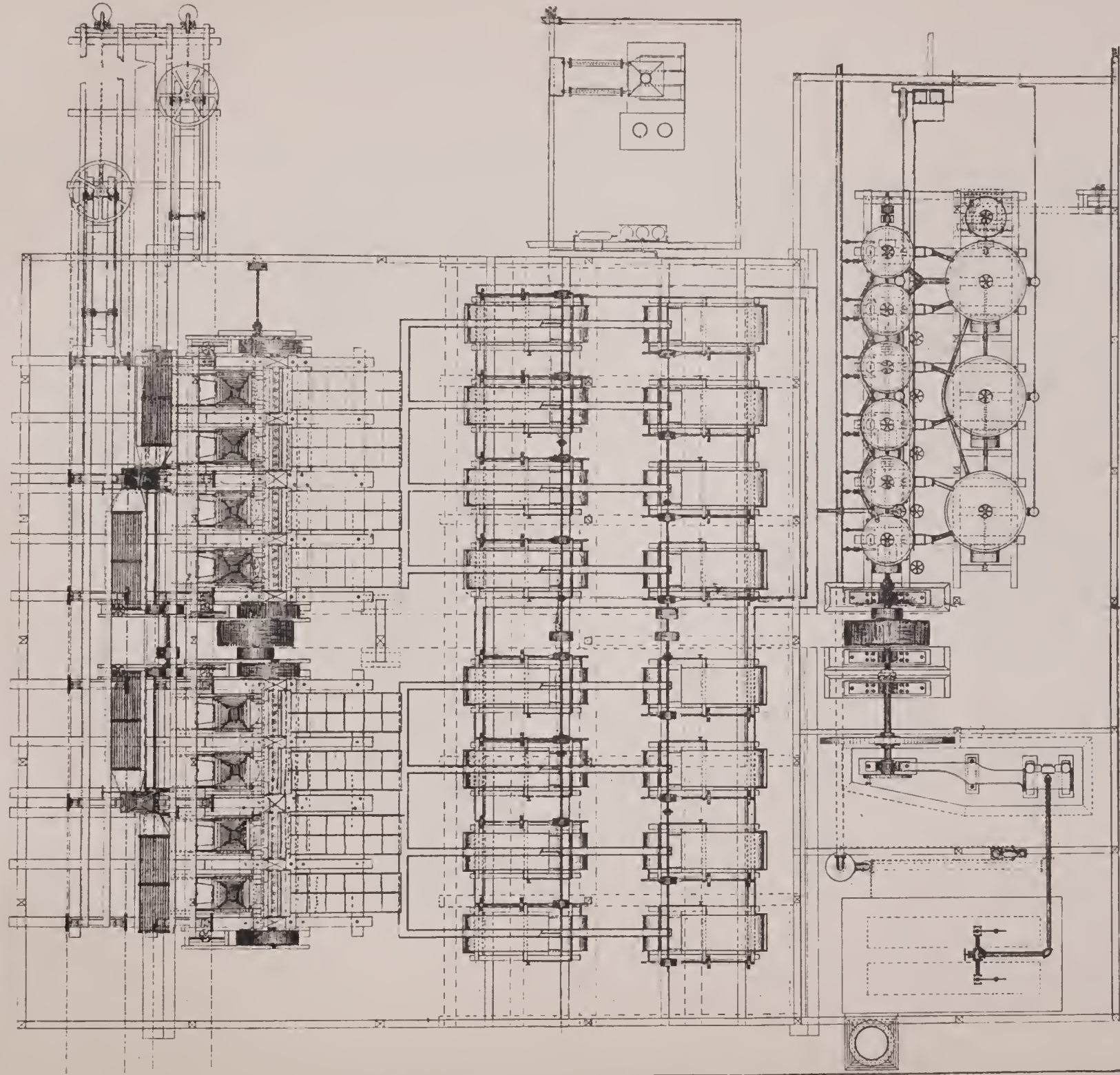
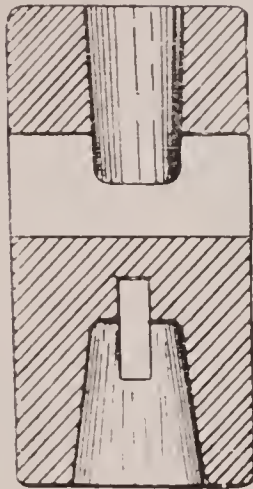
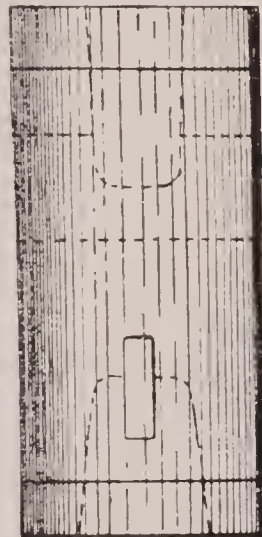


PLATE 6.

GROUND PLAN OF
 FORTY STAMP GOLD MILL WITH
 BATTERY, PAN AMALGAMATION AND
 TRIUMPH CONCENTRATORS.
 BUILT BY, MALTER, LIND & ROGERS.
 SAN FRANCISCO, CAL. U.S.A.

DETAILS OF BATTERY.—STAMP HEAD.

Cut 12.—Stamp Head
FORCut 13.—Stamp Head
FOR

Dry Crushing Battery. Wet Crushing Battery.

The stamp head is secured to the stamp stem on one end and on the other it is made to receive the shank of the stamp shoe.

The stamp head for wet crushing batteries is sometimes strengthened on both ends by heavy wrought iron bands as shown in cut 13.

The stamp heads are usually from 8 to 9 inches in diameter and from 14 to 18 inches in length, the size varying according to the desired weight of stamp.

STAMP STEMS.

Stamp stems are made of either hammered, rolled or calendered iron. It is from 3 to 4 inches in diameter, generally $3\frac{1}{4}$, and from 12 to 16 feet in length. Both its ends are turned tapering so as to receive and hold the stamp shoe and to permit its turning end for end.

CAM SHAFTS.

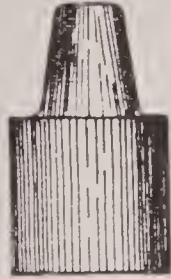
Cam shafts are made of hammered iron or of steel; they are usually from $4\frac{1}{2}$ to 6 inches in diameter, and should be provided with two keyseats placed at right angles, to serve in more securely fastening the cam.

The driving pulley is secured to the cam shaft, either at its middle or its end, as the construction of the battery frame may require.

BEARING BOXES.

The bearing boxes of cam shafts are of a peculiar construction, made so as to permit their being set upon "end wood" into a cut of the battery post, and with or without caps.

STAMP SHOE.

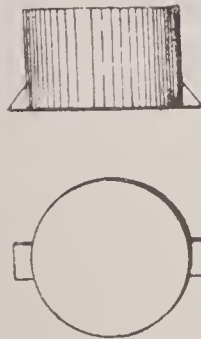


Cut 14.—Stamp Shoe.

The stamp shoe is secured by means of a taper shank and wooden wedges, to the lower end of the stamp head.

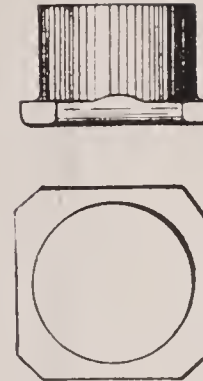
Stamp shoes we make of either cast steel or of a very hard quality of cast iron.

STAMP DIE.



Cut 15. - Die for Dry Crushing Battery.

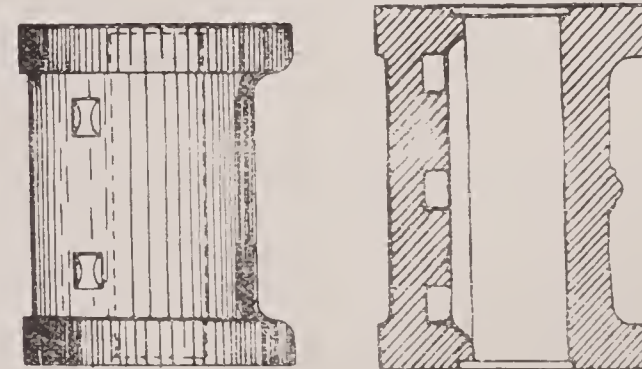
Cut 15 shows a die for a dry crushing battery. It is cylindrical in form, from 8 to 9 inches in diameter, and from 5 to 7 inches in height. Two taper projections are cast on its lower edge at opposite sides, by means of which it is held in place in the mortar. It is made of hardest cast iron or cast steel.



Cut 16.—Die for Wet Crushing Battery.

Cut 16 shows a stamp die for a wet crushing battery. It differs from the former in having a square base which keeps it from turning in the mortar.

TAPPET.



Cut 17.—Tappet.

Cut 17 shows two views of two and three key double face gib tappets. We make them of either steel or cast iron.

PLATE 7.

ELEVATION
OF
GOLD MILL
WITH
CONTINUOUS WORKING ARASTRA & PANS.
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL. U.S.A.
LITH. BRIMON & KEY S.F.

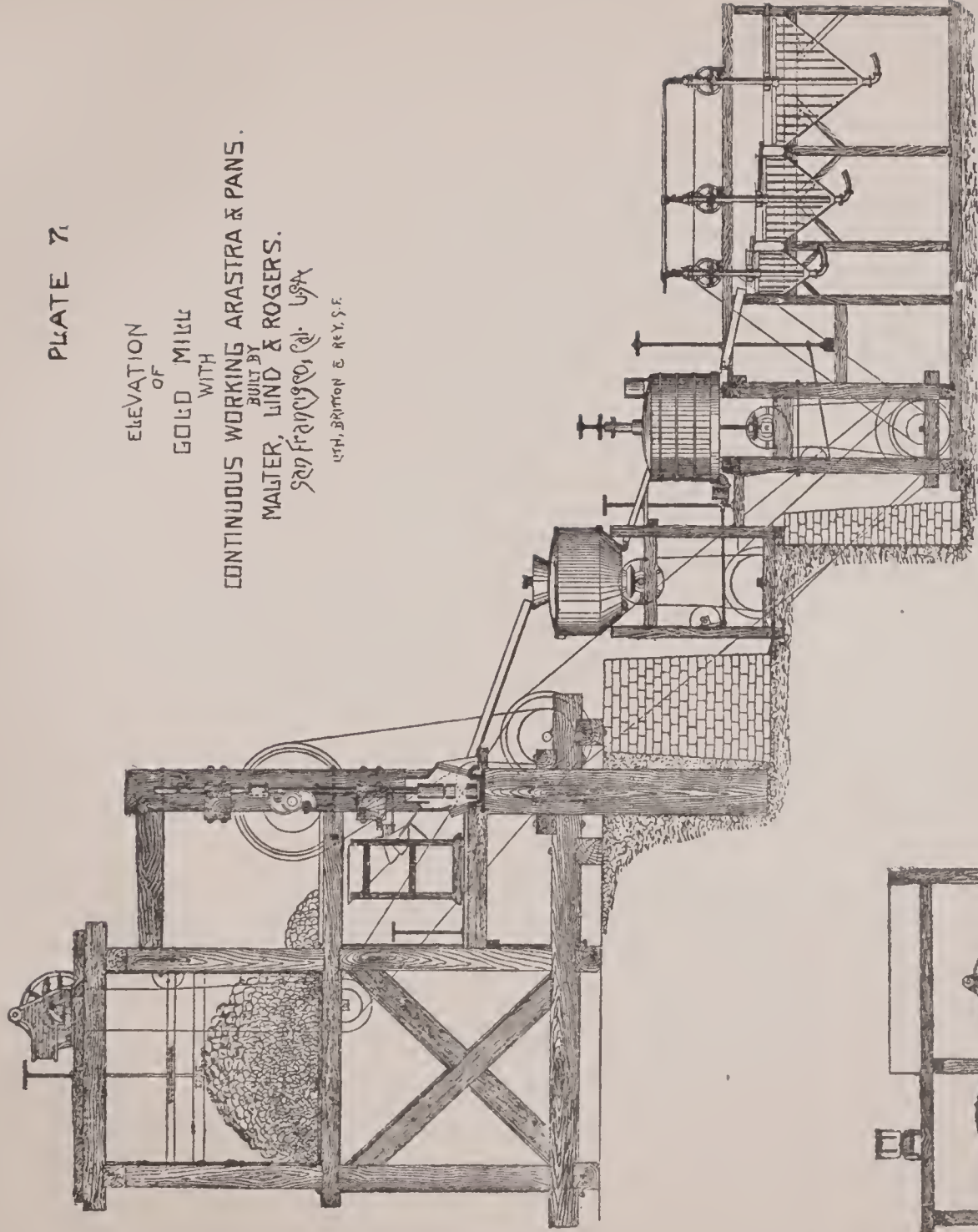
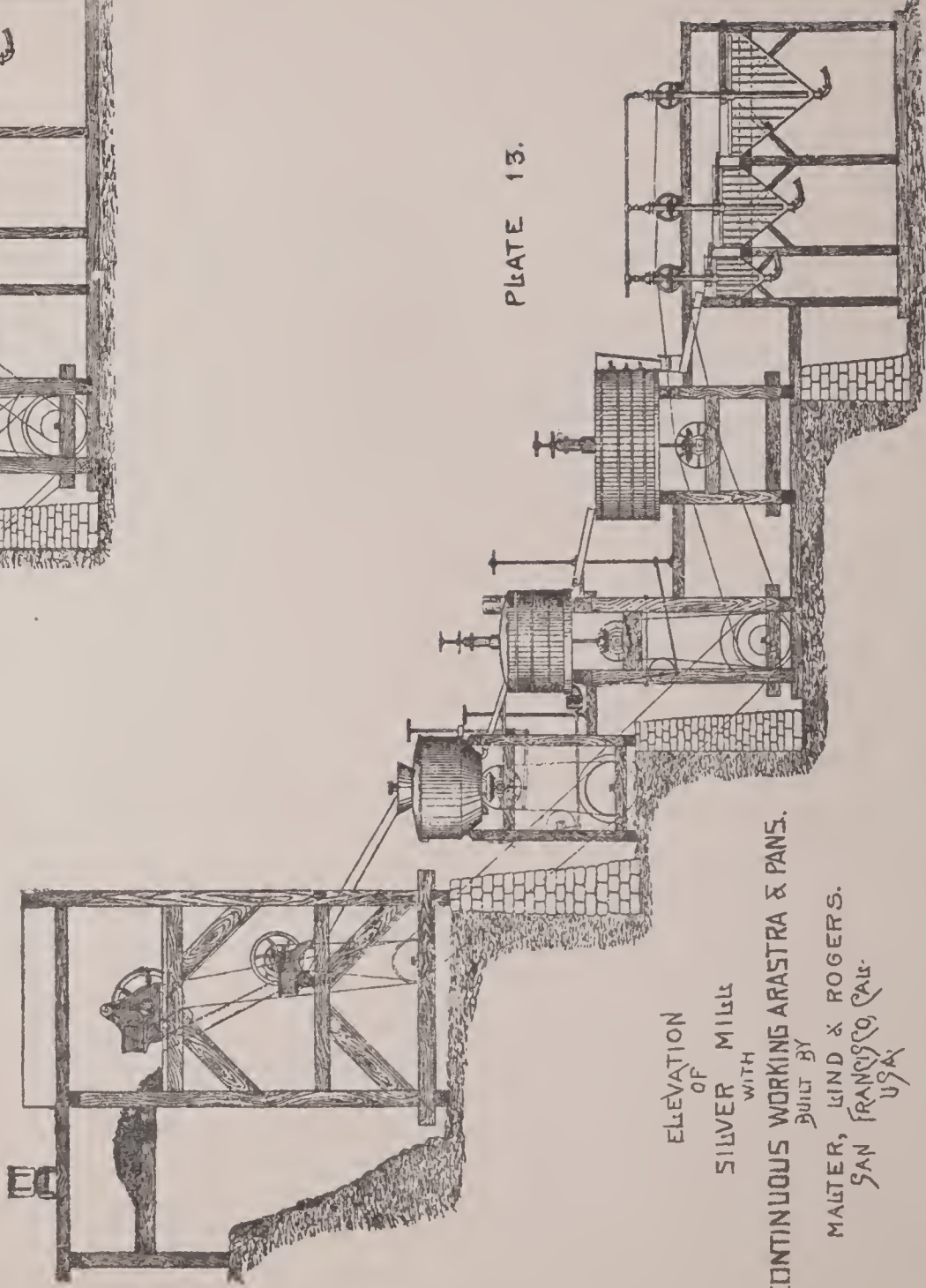


PLATE 13.

ELEVATION
OF
SILVER MILL
WITH
CONTINUOUS WORKING ARASTRA & PANS.
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL.
U.S.A.



CAMS.

The cams which serve to lift the stamp are now without exception made with two arms. Their curve should be so constructed as to allow the longest possible time for the lift of stamp, making the lift gradual and uniform, and still giving the stamp sufficient time to drop. The proper curve of cams is an evolute. Steel cams are preferable to those made of cast iron, they wear much longer, but cost more.

The lift of the stamp determines its efficiency. Seven to eleven inches is the usual lift. The cam should be made just long enough to give the desired lift; if it be made longer it starts the lift of the stamp by a blow against the tappet.

Care must be taken not to give the cam more face than the tappet may cover; else the face of the cam wears slanting, leaving a ridge upon its outer edge which crowds it away from the stem and tappets and causes breakage.

The cams should be secured to the cam shaft in such a manner as to drop the stamps in the following order:

One, four, two, five, three.

No two adjoining cams must drop in turn; else the ore be crowded towards one end or the other of the mortar.

DRIVING PULLEYS.

The pulleys which serve to turn the cam shaft are unexceptionally made of wood, fastened between heavy cast iron sleeve flanges to prevent their breaking in consequence of the jar to which they are subjected.

GUIDES FOR STAMP STEMS.

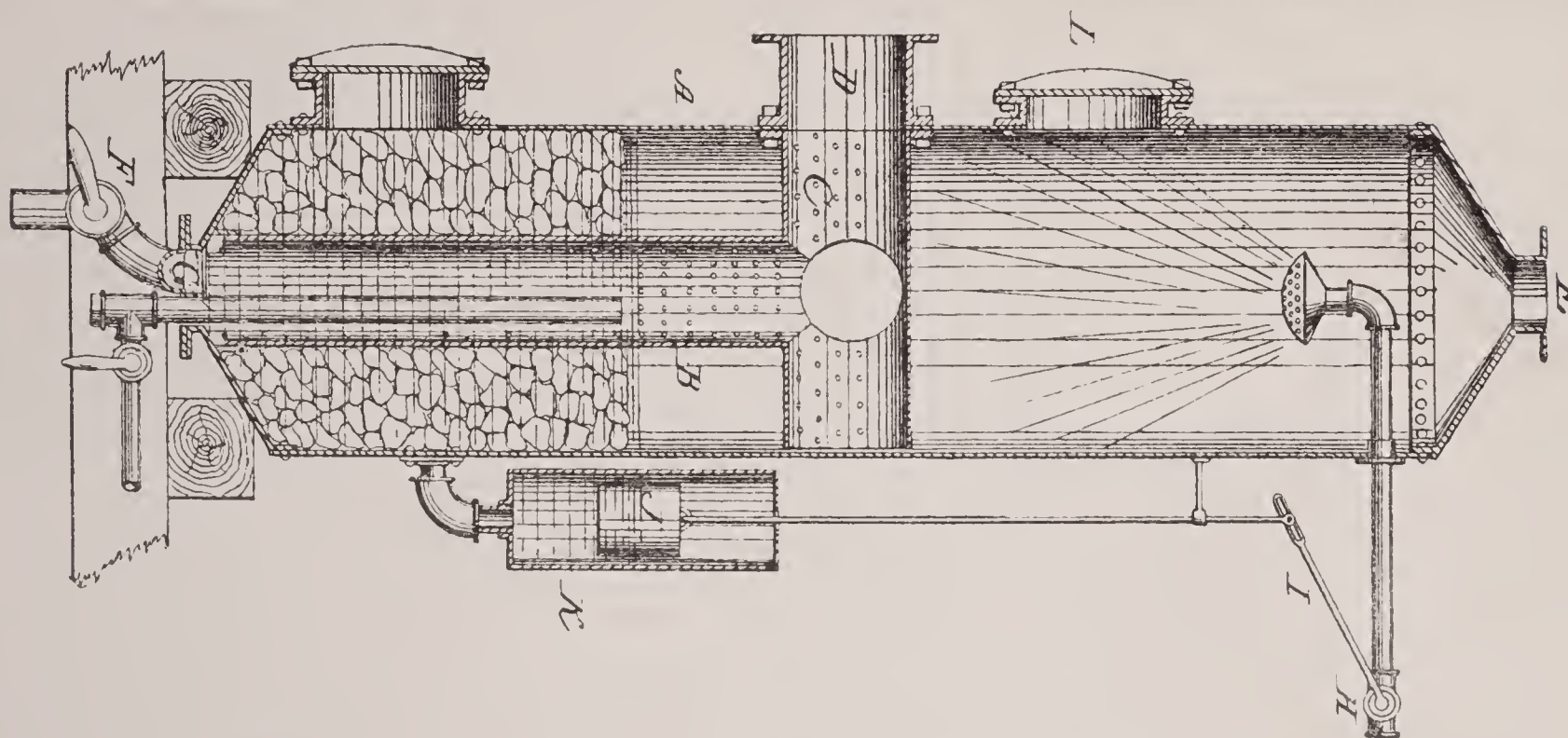
The guides for the stamp stems are mostly made of hard wood, in sets of five. A better, but more expensive way of making them, is of cast iron frames, so constructed as to retain separate wooden blocks for each stem.

LOCATING MILLSITES.

1st.—Select a site near a constant supply of good water, if not too far away from the producing mines.

2d.—If possible, locate the mill on a hillside where there is sufficient grade or fall so that when the ore is once delivered in the mill it will go through the different processes to the finish without requiring to be elevated.

3d.—Avoid a location which will entail expensive grading, as is found in blasting rocks or in very loose soils, necessitating the erection of strong retaining walls—also avoid sites, the lower part of which is not suitable for tailing reservoirs.



THE STANDARD PATENT WATER HEATER AND PURIFIER.

The plan of utilizing exhaust steam for heating feed water for boilers has been in use for many years, and numerous contrivances have been invented from time to time to better accomplish this purpose.

The nearer the boiling point to which the water can be brought before its introduction into the boiler, and the freer from impurities the water, the greater the saving in fuel in making steam, the longer the life of the boiler, and the easier to be kept clean.

To accomplish all of these results in the most thorough manner, we have designed and patented the standard heater and purifier, which we offer as superior to any heretofore in use. It can be more readily understood by reference to the cut.

The exhaust steam from the engine is conveyed by pipes to the nozzle (D) and into the tee-pipe (C) which is perforated with numerous holes near the top to permit the passage of the steam into the body of the heater. At the lower end of the pipe (C), there are large openings for the admission of the filtered feed water to the boiler feed pipe (B). The feed water is

supplied by means of the pipe valve and spray (H). The supply is controlled by means of an automatic arrangement consisting of the lever (I), the valve (H) and the float (J), which works in the cylinder (K).

The steam rising from the pipe (C) is quickly condensed by the spray of the feed water as it falls upon the filtering substance below.

Charcoal, cobble stones, shavings or whatever is best adapted to take up the particular impurities in the water may be used as filtering material. The water percolating through the filter passes to the bottom of the heater and through the opening in the lower end of the pipe (G) to the boiler feed pipe (B) which extends to nearly the surface of the water in the heater, when the feed water is taken to avoid taking any oil that might run in on the surface as well as take any impurities which may have settled in the bottom of the heater. The impurities may be blown off through the blow off cock (F). The uncondensed steam passes out of the heater at (E).

Convenient man holes and doors are provided for the supplying and removing of filtering material.

The heaters are *simple, practical* and efficient. They heat the water to a temperature near the boiling point besides thoroughly purifying it.

PLATE 8.

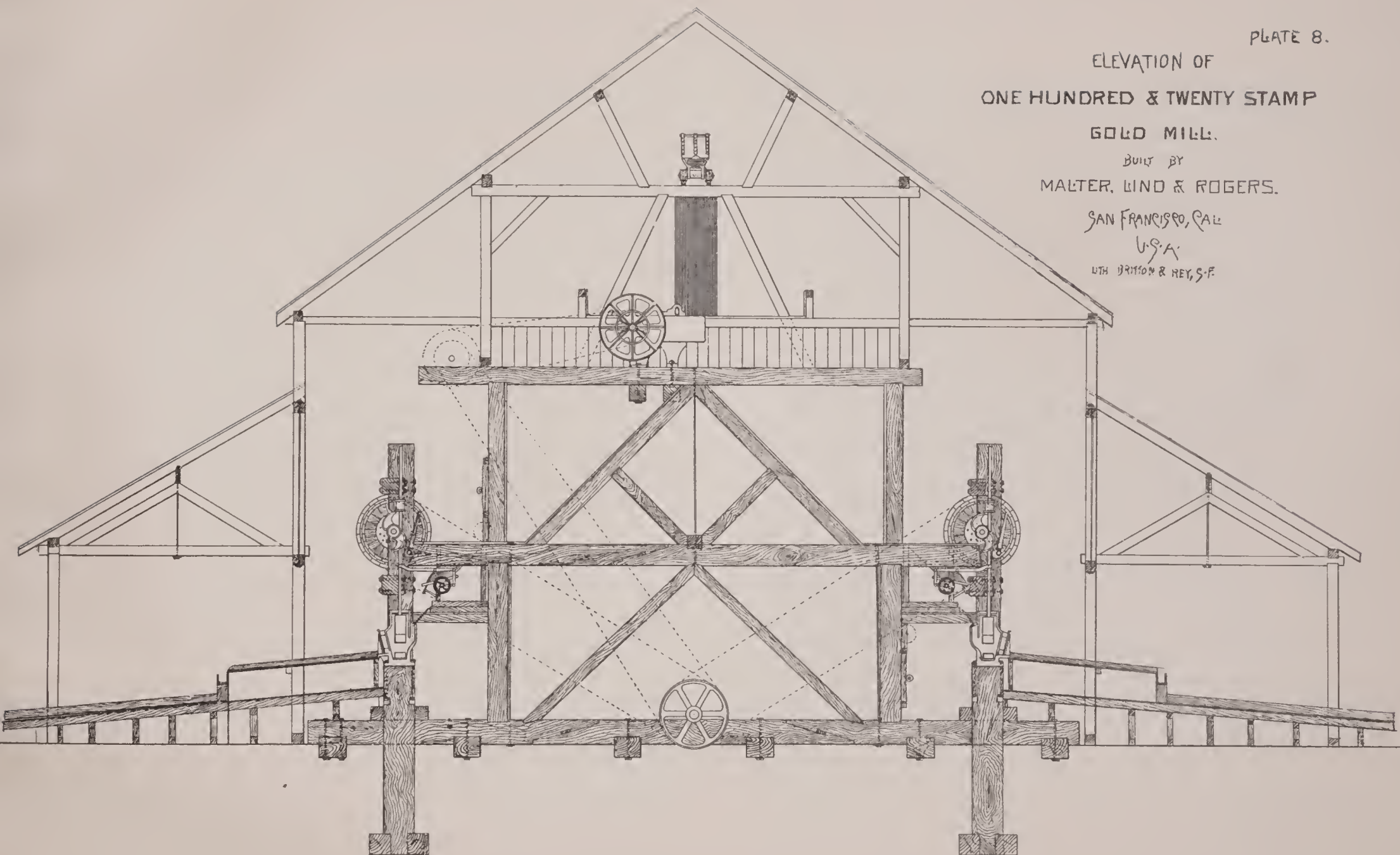
ELEVATION OF
ONE HUNDRED & TWENTY STAMP
GOLD MILL.

BUILT BY
MALTER, LIND & ROGERS.

SAN FRANCISCO, CAL.

U.S.A.

WITH BRITTON & REY, S.F.



CONTINUOUS WORKING TAILING CON- CENTRATOR.

The engraving on next page shows the longitudinal section of the continuous working apparatus, for the concentration of ore tailings. It consists of one or more cylindrical vessels placed in upright positions, having funnel-shaped bottoms. When more than one vessel is used, they are placed in a row, in order to pass the ore from one to the other, each succeeding one being increased in size. The ore to be concentrated is introduced by means of a spout, on one side of the vessel at its upper rim.

An upright pipe is suspended to the center of the vessel for the purpose of introducing a steady stream of clear water, just above the lowest point of the funnel. The lower end of this pipe is held in place by means of a spider.

This upright pipe serves as shaft, to which stirrers are attached, which can be made to revolve with the upright pipe. The shaft is used for the purpose of putting the mass of pulp in the vessel into rotating motion.

At a point a few inches below the level of the top of the vessel, is a discharge bowl. It encircles the upright shaft, and is there supported.

A spout is secured into the side of the discharge bowl, and serves in leading the overflow or tailings, from each vessel away, or into the next or succeeding vessel.

At the bottom of the funnel, is attached an outlet pipe for the concentrated sands. The end of the pipe is fitted with a valve, in order to regulate the size of the discharge opening; the pipe itself so swivels, that the discharge can be raised or lowered, and the output facilities increased or retarded by controlling the quantity of water it passes out, and serves as an agent to carry away the concentrates.

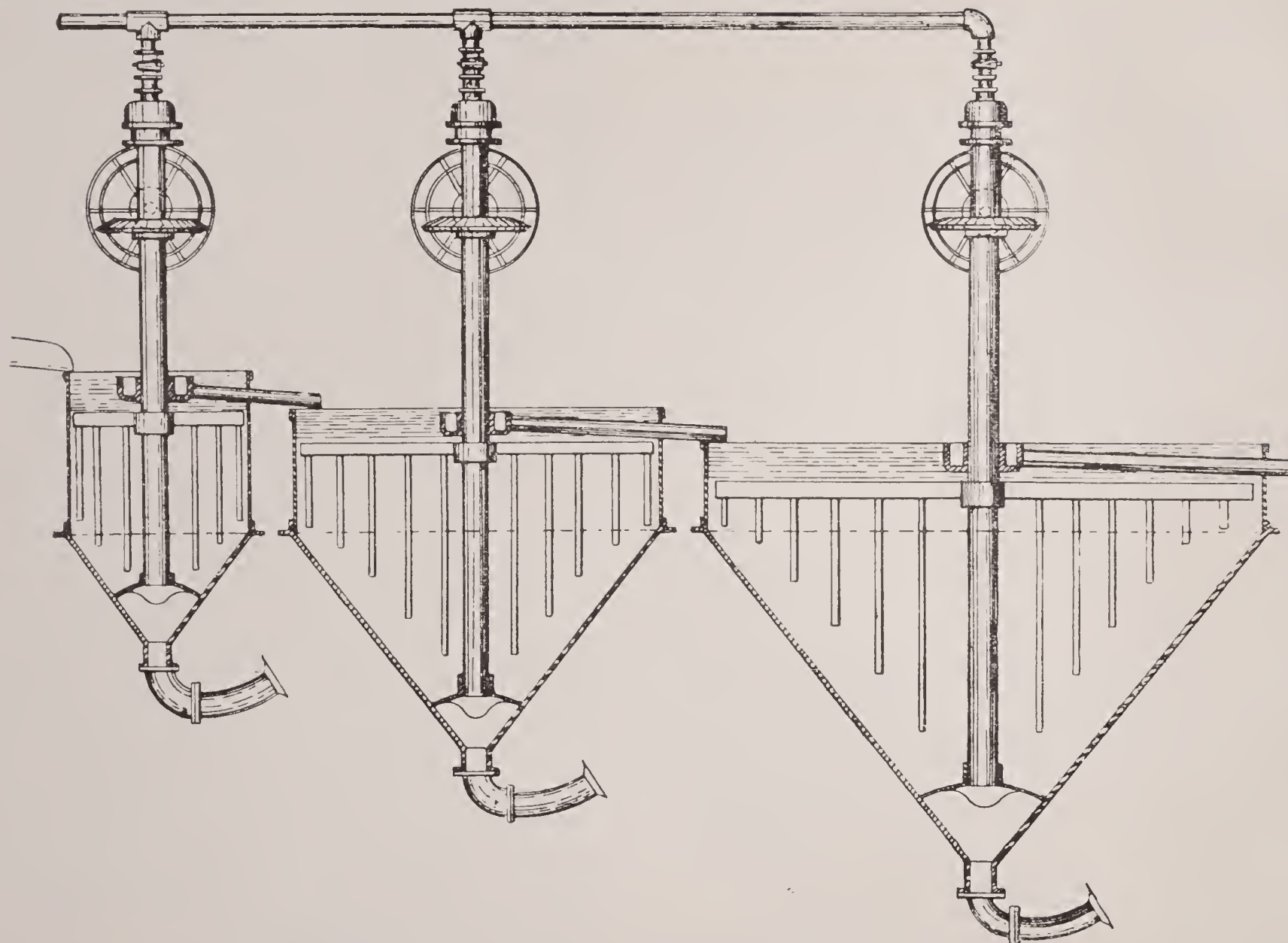
As the ore to be concentrated falls over the side of the vessel into the water contained in it, it sinks down towards

the bottom, and the coarser and heavier with more force than the finer and lighter, as it passes toward the bottom of the cone, it meets the clear water, introduced there, which creates a rising current carrying upward toward the discharge bowl the light material, while the heavy sinks through it into the discharge pipe. If the stirrer arms are set in motion they cause the heavier particles of ore to gather about the circumference of the vessel, leaving the finer and lighter portions near its center, where an upward current carries them into the bowl, while the downward tendency of the coarser is stronger at the circumference of the vessel, the upward current is greatest at the center.

The great advantage of this apparatus over any similar apparatus or any other contrivance for concentrating, consists in its simplicity, cheapness of the construction and operation, and durability, its efficacy and the ease with which it can be adjusted. The amount of water introduced at the bottom of the funnel, and the raising and lowering of the discharge pipe entirely controls the degree of concentration.

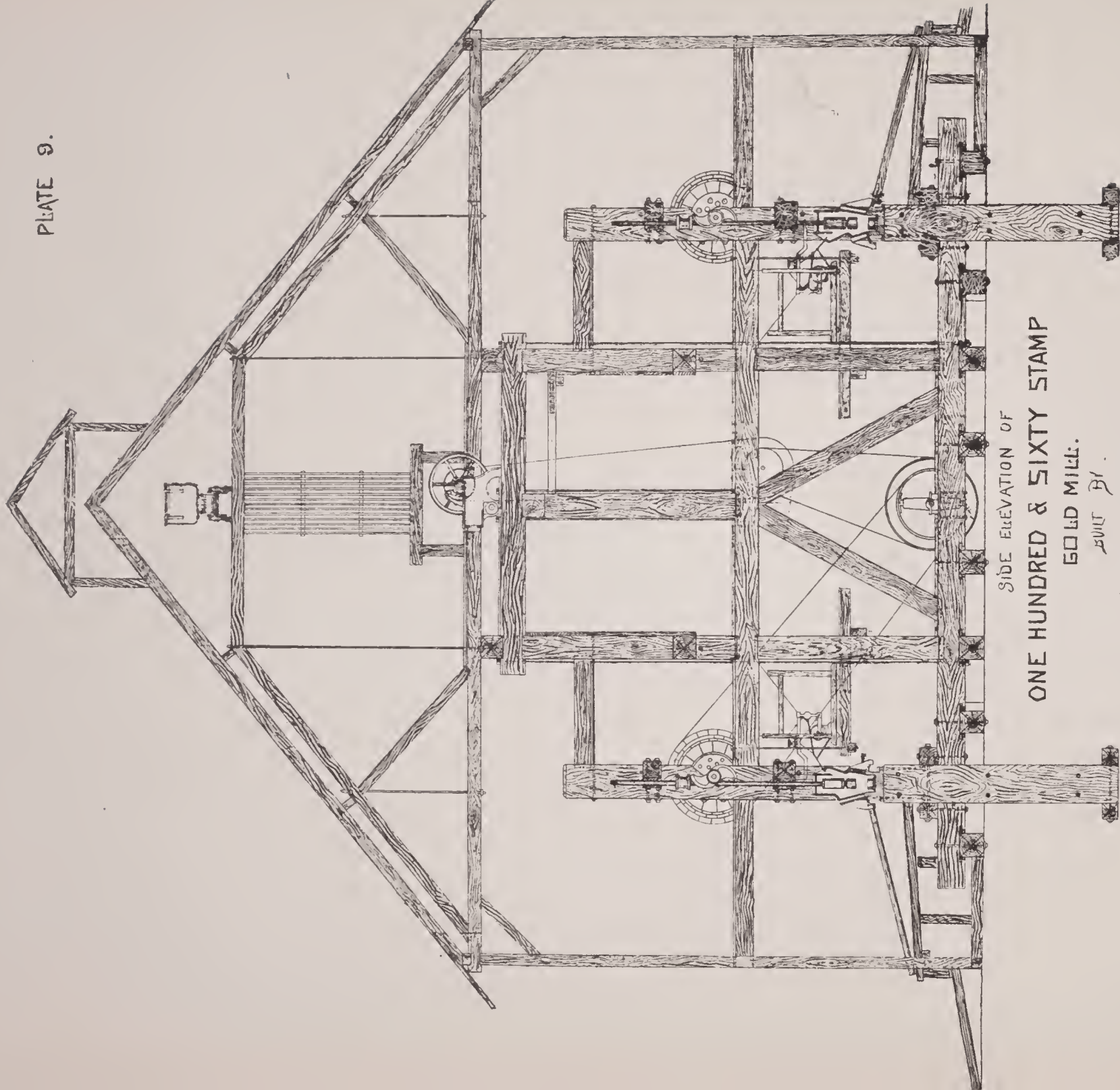
The apparatus is easily attached to any silver mill, as it serves efficiently to *separate the valuable from the worthless tailings, without cost of operation.* In mills where the ore is being concentrated on tables, or other concentrators, this apparatus will be found very efficient, in preparing ore, before concentration, and by making it separate the coarser from the finer. For all concentrating apparatuses, which work on the principles of inclined planes, it will be found to concentrate cleaner and to a higher percentage.

If the ore is first separated in the above apparatus, according to size and weight, this apparatus serves in separating the light and fine worthless sands of the surplus water, from the valuable portion of the ore, thus diminishing the quantity decreasing the number of concentrating machines, required in final concentration.



MALTER'S PATENT TAILING CONCENTRATORS.

PLATE 9.



SIDE ELEVATION OF
ONE HUNDRED & SIXTY STAMP
GOLD MILL.

BUILT BY

MALLET, LIND & ROGERS.

SAN FRANCISCO, CAL.
U.S.A.

WM. BRITTON & CO. S.F.

SMELTING OF ORES.

Argentiferous lead and copper ores containing more than fifteen per cent of base metal, can be more advantageously reduced by smelting than by the milling process.

If they are rich enough in base metal, and contain a gangue favorable to forming desirable slags, or, if fluxes can be easily and cheaply obtained, such ores can be smelted without concentration: otherwise, they can be concentrated at an expense of 50 cents to \$1 per ton previous to being smelted.

"For the smelting of such ores, and for the reduction of all other lead and silver ores, we furnish complete plants and erect them at the mines." As regards the concentration of ores, we refer to our remarks on the process of concentration and the machinery therefore.

Either reverberatory or blast furnaces may be used to matte the metals and separate them from the gangue, of either the ores or their concentrates. The reverberatory has some advantages over the latter furnace, especially in copper smelting, it is, however, seldom used in our mining districts, for the reason that only ores of a peculiar character can be smelted in it with profit, and that such ores are rare on this continent.

The principal advantages of the reverberatory furnace over the blast furnace are:

- 1st. No blowing engines or pressure blowers are required.
- 2d. Raw fuel can be used.
- 3d. The manipulation is easier to be controlled.

The ores best suited for smelting in reverberatory furnaces are those of a high grade with calcareous gangue containing none or but a limited amount of refractory metals.

Lead ores containing considerable zinc, copper, antimony, arsenic, etc., cause the formation of rich residues, and often also a volatilization of the precious metals which the ore may contain.

Silicious ores, containing more than five per cent of quartz, are entirely unfit for the reduction by reverberatory process, as silicate of lead is formed which impedes the operation and causes great loss in residues, unless these residues are resmelted in blast furnaces, and then the double process entails great additional expense. The blast furnace process of smelting both lead and copper ores is almost exclusively used at our mines. The high prices of labor and the refractory character of our ores make it a more desirable process than the use of the English reverberatory just referred to.

In order to smelt ores successfully, it is necessary to first ascertain the mineralogical character and the chemical properties of the gangue.

A mechanical separation of the matrix from the metallic portion of the ore, and perhaps a preparatory roasting of the ore, should precede the smelting in all cases where the percentage of metal in the ores is low, and where the fluxing is expensive and a pure and marketable bullion cannot otherwise be obtained. By concentration it is possible to get rid of zinc blend, which causes loss and trouble in the furnace, and of a great portion of the gangue, which it would be expensive to flux and reduce to a slag in the furnace.

Quartz is infusible by itself and so is lime; but if the two are mixed in proper proportion and exposed to the necessary heat, a fusible compound results. Experience has shown that the single compounds of silica and lime, or of alumina, magnesia, etc., are less fusible than the double compounds of, say silicate of lime and silicate of alumina. When replacing one of these bases by alkalis or the proto-oxides of heavy metals as, for instance, iron or manganese, the fusibility of the slag may be increased within certain limits, it depends principally upon the proportion of the oxygen in the silica to the oxygen in the bases contained in it.

Fluxes are mineral substances which serve to liquify others not fusible by themselves. It sometimes occurs that an ore contains all the slag-forming ingredients in proper proportions, as for example, most of the ores of Eureka District, Nevada.

The usual bases of slags are lime, iron-oxide, alumina, magnesia, manganese-oxide, zinc-oxide, some alkalies from the ashes of the fuel, etc.

Silicic acid - - -	(Si. o, 3)	21½	silicium to 24 parts oxygen.
Lime - - - - -	(Ca. o,)	20	calcium to 8 " "
Proto-oxide of iron (Fe. o,)	28	iron to 8	" "
Magnesia - - - -	(Mg. o,)	12	magnesia to 8 " "

With the assistance of the above formulae it will be easy to compute the percentage of oxygen in the bases and acid of slags. According to the proportion existing between the oxygen of the silica and the oxygen of the bases, four classes of fusible slags are distinguished. If the constitution of silicic acid is considered to be Si_2O_3 , of course the denotation of the slags mentioned below would be changed.

First—Tri-silicates, in which the silica contains three times the amount of the oxygen present in the bases. As there is over fifty per cent of silica in such slags, they require too high a temperature for their formation to be feasible in lead smelting.

Second—Bi-silicates contain generally fifty per cent of silicic acid and fifty per cent of the bases, the amount of oxygen in the silica being twice that in the bases.

Third—Singulo-silicates averaging thirty per cent silicic acid, seventy per cent bases—the amount of oxygen in silica and bases being equal.

Fourth—Sub-silicates with twenty per cent silicic acid and eighty per cent bases, the amount of oxygen being less in the silica than in the bases.

The latter two slags are termed "basic slags" because the bases predominate in them over the silicic acid. The former two are termed "acid slags" because the acid predominates in them. Complicated formulae, for the fluxing of ores, have been established from accurate analysis of various slags, but as the ores or their slags are rarely constant compounds, these formulae have little practical value for the smelter, who is generally content to know the percentage of silica in the ore, and the quantity of useful metal which he is endeavoring to obtain. The practical smelter, generally guesses at the flux required, by the appearance of his slag in both the fused or solid states. An occasional analysis is usually deemed sufficient when the ore is of uniform character, and when the appearance of the most favorable slag is once established and known to the manipulator of the furnace. The carelessness of smelters, in neglecting to constantly analyze their ores and slag, and to vary their fluxes accordingly, has caused the immense loss of precious metals at most of the western smelting works.

The most desirable slag for lead smelting is the singulo-silicate or a mixture of bi-silicate with the former proto-oxide of iron prevailing in the bases. Such singulo-silicate slag runs with a bright red color, and solidifies very quickly with turgescence. The bubbles when bursting discharge bluish gases, sometimes flames. These slags have a vitreous metallic luster and a higher specific gravity than the bi-silicates and are therefore more liable to entangle metallic particles.

If lime and alumina are the prevalent bases, the heat required for their formation is much higher than if proto-oxide of iron prevails, and the slags form incohesive lumps, run short and pasty. After solidification, they appear honey-combed or like pumice stone, grayish-green in color, with a radiated or laminar crystalline structure.

40 STAMP WET CRUSHING STAMP MILL.

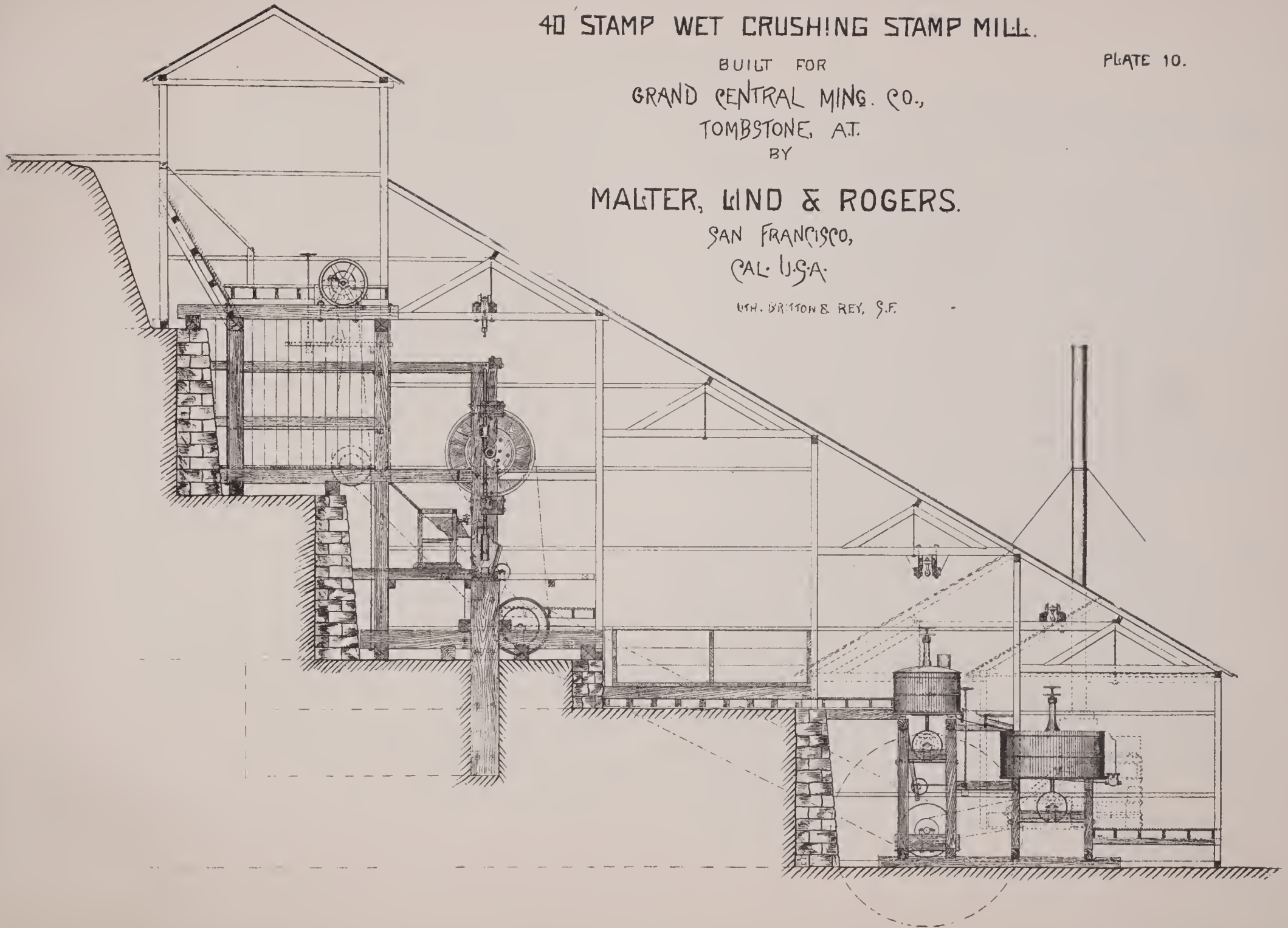
PLATE 10.

BUILT FOR
GRAND CENTRAL MINING CO.,
TOMBSTONE, AT.
BY

MALTER, LIND & ROGERS.

SAN FRANCISCO,
CAL. U.S.A.

W.H. BRITTON & REY, S.F.



An earthy singulo-silicate slag is the least desirable for the lead smelter. Bi-silicates form under a higher temperature, and consequently involve a larger consumption of fuel than the singulo-silicates. They flow slowly like molasses, solidify but gradually, without cracking or bursting, and are not so liable to form accretions in the furnace as the basic slags. After solidifying, they appear vitreous, have a conchoidal fracture, and are generally of a blackish color. Being saturated with silicious acid, they do not corrode the furnace lining as much as the basic slags; their specific gravity is lower and metallic particles separate more easily from them, but they are apt to take up oxide of lead and cause a loss of that metal.

The formation of sub-silicate slags should be avoided as they are very detrimental to lead smelting. They have a high specific gravity, and very apt to form accretions in the furnace and attack the lining, thus shortening the time of a furnace run sometimes to a few days if there is no water jacket to the furnace, besides they don't permit a clean separation from the metal. If proto-oxide of iron is their principal base they run in streams like fluid litharge and congeal very quickly.

As fluxes, the following substances are used:

First—Iron-stone is a very efficient agent to slag, quartz being reduced in the furnace to proto-oxide of iron which has a strong affinity for quartz, and forms an easily fusible slag. The best quality of iron-stone is hematite or magnetite. Hydrated iron ores are very easily reduced to metallic iron, and, therefore, should be burned or partially roasted before being put into the furnaces. If free from quartz or slag, iron-stone may be put into the furnace in pieces as large as a man's fist. Iron ores are also used as desulphurizing agents.

Second—Soda, alkalies and potassium, which are obtainable in rare cases, are even better than iron-stone as a solving agent of quartz. They are not used, being rare and commanding too high a price.

Third—Lime is a partial substitute for iron-stone as a solving agent for quartz. It should be reduced to the size of pigeon eggs. Burnt lime is also used and is theoretically better, but is apt to crumble into fine dust which is either blown out the top of the furnace or too readily falls through interstices of coal and ore, and does not always unite at the proper time and in the proper proportions with the silica. Lime alone cannot be used as a slaging agent for quartz. Lime slag is smeary, does not flow well, is apt to clog the furnace, and the metal does not separate easily from it.

Fourth—Clay can only be used in small quantities as a partial substitute for quartz; it is apt to go to the bottom of the furnace without uniting with a base, and there forms incandescent lumps which attach themselves to the walls and hearth of the furnace.

Fifth—Salt, which in some parts of this country is very abundant, should not be used as a flux, being worse than useless. It does not unite with the gangue but forms a very light slag by itself, which floats on top of the other slags. Besides, salt may form volatile chlorides of lead and silver, thus causing loss of metal.

Sixth—Iron pyrites, if thoroughly roasted, are a good flux, but if used raw, have no action on the gangue, but produce a brittle sulphuretted metal or matte.

Seventh—Quartz, in form of gravel could be used to furnish acid for the slag where the gangue of the ore is basic.

Eighth—Acid slags may be used to take up bases and act as solvent agents.

Ninth—Basic slags are used to unite with quartz and act as diluting agents.

Tenth—Metallic iron is used in form of scraps—small pieces of wrought or cast iron—to decompose galena, thereby forming sulphuret of iron (iron-matte) and metallic lead, thus rendering a previous roasting of galena ores unnecessary; if there is silver in the ore a great deal of it would go into the matte.

Eleventh—Litharge may be used in fluxing silver ores, which are poor in lead, to prevent the silver from going into the matte.

Twelfth—Cinders or semi-fused matte resultant from previous smelting, may serve to extract the metal.

The fuel most generally used in the blast furnace is charcoal. Coal burnt of the nut-pine is considered the best.

Coke can be used to much advantage, but it requires a greater pressure of blast than charcoal to effect its perfect combustion.

The pressure blowers generally used to supply the blast for copper or lead furnaces, are not always sufficient to permit of the economical use of coke.

One ton of coke produces about the same effect as two hundred bushel of charcoal. Fine ore generally requires more fuel than coarse ore.

The amount of fuel required to smelt one ton of ore, of course, depends upon the character of the coal, the ore, the fluxes, and the construction and manipulation of the furnace.

None but pure quartz sand should be used in *fire-proof mortar around copper furnaces*, and *nothing but fire clay around lead furnaces*. Lime mortar is not fit to be used as it crumbles off in the heat, combines with the slag and allows it to creep through the joints. The stones or fire bricks must be laid as close as possible and all large joints must be avoided. The area of the hearth is now generally made about half that of the throat, and even less. Small furnaces usually have a circular form of cross section.

Larger furnaces are more frequently made oblong in their cross sections as the blast can be better divided through the ore. Practice has shown that the loss of metal in the slag is less in oblong furnaces, than in round ones, under otherwise similar circumstances and conditions. The number of tuyeres and their position determine in a great measure the successful working of a furnace. At the level of the tuyeres, the temperature of the furnace is highest and the separation of the the metal from the gangue, and the formation of matte and slag takes place there, the heavier metal sinking downward, the slag swimming on top of it. If the tuyeres are placed too low the heat will be too great near the surface of the molten metal which may cause a great loss in volatilization of metal. The lowest point of the hearth must not be too far below the level of the tuyeres, as the metal may get too cold to be drawn off; thirty to forty inches is about a proper depth of hearth for lead smelting, and for copper about eighteen to twenty-four inches. The number of tuyeres must be in proportion to the size of the furnace, depending somewhat on the character of the ore and the pressure of the blast used. About two inches of tuyere area to one square foot of hearth area is a standard proportion. The height of the furnace above the tuyeres is rarely less than ten feet, and considerable more if a high heat is desired.

TEN STAMP SILVER MILL,

WITH

PAN AMALGAMATION.

BUILT BY

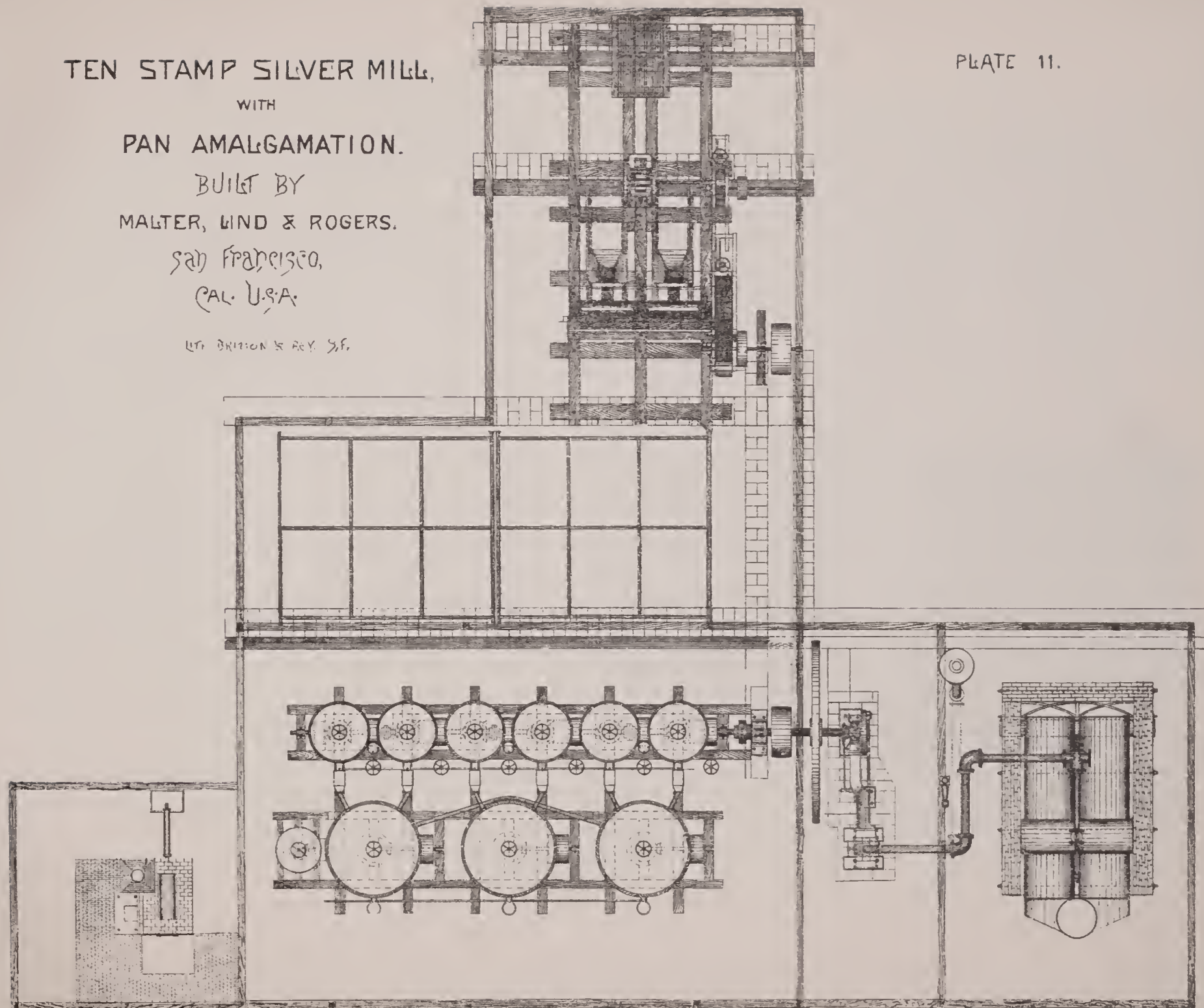
MALTER, WIND & ROGERS.

SAN FRANCISCO,

CAL. U.S.A.

LET. BRITTON & REY. S.F.

PLATE 11.



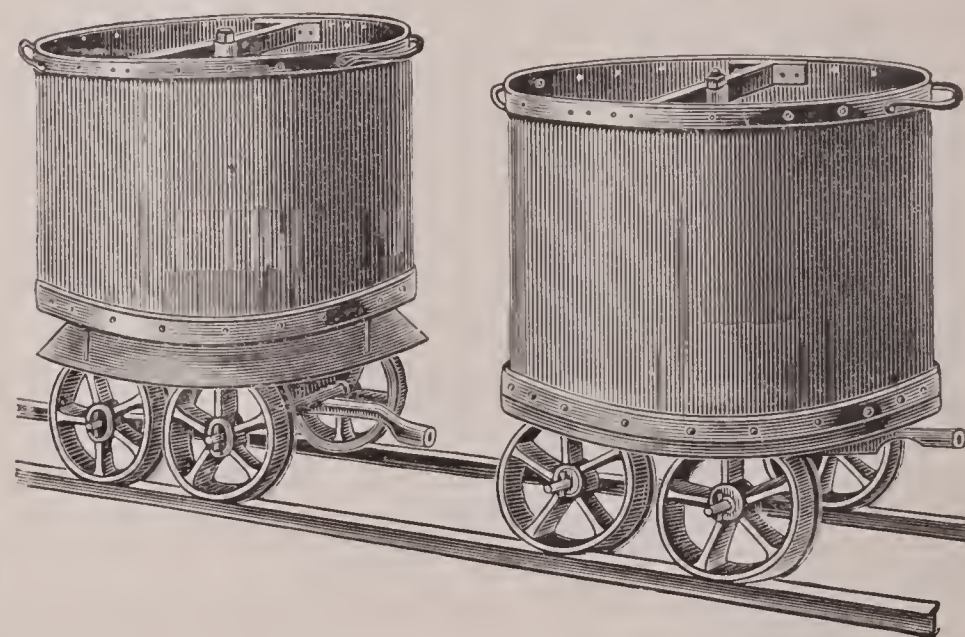
The furnaces must be low if basic ores are to be smelted, especially if they carry a great deal of oxide of iron which might be reduced to metallic iron in the great heat of a higher furnace.

High furnaces are required for argillaceous or quartz ores where a bi-silicate slag is desired. In high furnaces, a higher temperature may be obtained at a less expense in fuel than is possible in low furnaces. High furnaces economize fuel, but a low furnace is easier manipulated when deranged than a high one. Where the character of the ore constantly changes, a low furnace is preferable for that reason.

The manner of feeding or charging a furnace effects its work materially. The ore, fuel and fluxes must be introduced in proper proportions and spread uniformly over the top.

Charge scales, so-called, should always be used, upon which the ore, fuel and fluxes can be weighed without any change of weights. The metallurgist, after having determined the proportions of the materials to be charged, sets the scales, and the furnace feeder has nothing more to do but to place the charge car upon the scales and load it until it balances for each material. All guess work is thus avoided and a uniform result is ensured.

Cuts 3 and 4 show a charge car. It rolls upon rails which extend over the top of furnace and the scales. The car, after having been loaded on the scales, is placed over the shaft of the furnace, the lever which lifts the sides is pressed down by the foot, and the charge drops out beneath them in form of a perfect circle, uniformly spreading over the top of the furnace. Smaller furnaces, having the smoke-stack on top, are generally provided with a feed-hole in their side just beneath the stack; through this hole the materials to be charged are introduced by means of a shovel. This is not a desirable method, and may give rise to a great many irregularities if the feeder is in the least careless.



No. 3

Charge Car.

No. 4

The smoke and the fumes of the furnace can be carried away either by a smoke-stack placed directly on top of the furnace, or by a flue, which may start from the side or from the top of the furnace, and extend horizontally to a chimney. Several furnaces may be thus connected with one chimney. These connecting flues may also serve as dust chambers. Funnel shaped chambers are often attached to them extending downward and having a gate at the lowest point; the accumulated dust can be readily taken from them. When the ore is fine, the furnace low, and a strong blast is used, a great deal of dust may be carried away with the fumes, and a considerable loss occur in this way, which can be overcome, in a measure, by these flue chambers.

A new furnace must be heated gradually, to permit the moisture in the masonry to escape; several days or weeks, may be consumed in drying a new furnace. After drying is finished, the bottom stone is covered with fire-clay, the lead-well and the top holes are lined, and the dam covered with fire proof material.

Most all lead furnaces are now provided with lead-wells, or so-called syphon-taps. The formation of "sows" is in a great measure, prevented by the automatic syphon-tap, which carries the molten lead continuously out from the bottom of the furnace as fast as it is reduced inside, and if much of the iron in the furnace be reduced to metallic state, it will swim on top of the lead, always at the same level. It can never reach the bottom of the furnace, but remains exposed to the oxidizing influence of the blast, which causes it to be carried into the slag.

As the automatic syphon taps the furnace at its bottom, none but the heaviest metal is being carried out; iron and zinc, etc., being lighter than lead, swim on the surface of the molten mass; and are kept exposed to the oxidizing heat of the blast, thus being largely carried off in the slag.

Carbonate ores, if they contain the slag favoring ingredients, will often produce pure metal without further fluxing, but Galena ores, although they contain all favorable slag ingredients, must be fluxed with metallic iron to absorb the sulphur of the galena, to produce metallic lead; or if not so fluxed, the galena ores must be subjected to a roasting or calcining operation before smelting them.

Sulphuretted copper ores cannot be well fluxed with iron, as the iron matte which would result could not be easily parted from the copper, therefore such ores should be calcined or roasted to enrich the matte. This is best done after the ores are pulverized, in a reverberatory furnace, but as fine pulverized ores cannot be well smelted in a blast furnace, either reverberatory smelting furnaces are used, as is done in Butte, Montana, or the ore is roasted and pulverized and made into adobies—in brick form—and then smelted in a blast furnace. Attempts to roast highly sulphuretted copper ores in heaps without previously pulverizing them, do not generally give satisfactory results. The calcining furnace shown in engraving on page 35, is best suited for the roasting of ores in lumps, and will give more satisfactory results than roasting the ore in heaps.

If the sulphuretted ores are crushed and roasted in a reverberatory furnace, the heat can be increased at the finish of the roasting so as to partly melt the roasted ore and form lumps, which can be broken into convenient pieces for smelting.

Ores yielding a very basic slag may be introduced into the furnace in large pieces, and still be easily smelted; silicious and calcareous ores ought to be crushed in rolls, or at least in rock breakers, to the size of eggs.

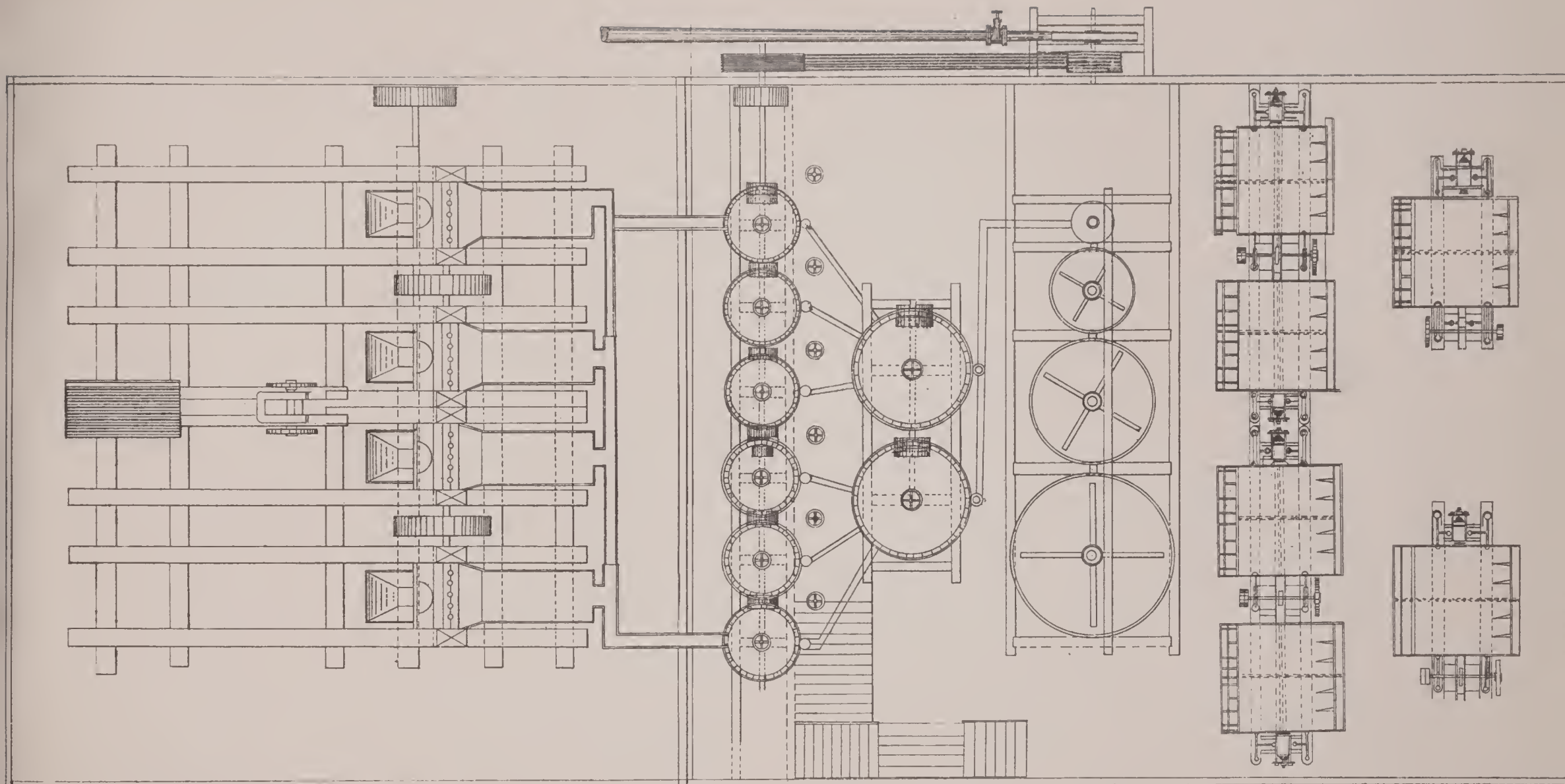


PLATE 12.

GROUND PLAN OF
 TWENTY STAMP SILVER MILL WITH
 TAILING CONCENTRATORS.
 BUILT BY. MAJER, LIND & ROGERS.
 SAN FRANCISCO.

Metallic iron does not always find heat enough in lead furnaces to be run out with the slag, and hence is apt to congeal in the hearth, and forms what the smelter calls "sows" or "horses," etc. Very fine ores should be worked into adobes (unburnt bricks) like the pulverized and roasted ores, to prevent their getting about the tuyeres, choking the blast and deranging the furnace. An ordinary brick machine does not answer the purpose of making these bricks, as they are apt to crumble too easily if not made under heavy pressure. We can furnish proper brick machines at a cost of from one thousand to three thousand dollars, capable of making from ten thousand to fifty thousand bricks daily.

The Hesse smelting furnace is one of the best constructed and equipped furnaces in use in our mining regions. The cut on next page shows a sectional view of it. The water jackets are made in sections secured together in such manner that any portion of it can be taken down without disturbing the rest. This jacket does not extend in height as much as is generally the practice in furnace building. Several courses of brick clamped together in sections, find room above it, and below the iron plate that supports the upper portion of the furnace. In case the furnace becomes deranged from any cause whatever one or more of these sections of brick can be easily removed and the furnace can be entered with crow bars, etc.

The steam that may be generated in the jacket is carried away by pipes.

The molten lead is not dipped from the lead well, as is ordinarily done, but an automatic ladle is so arranged upon a turn table that the bullion mold may be filled without lifting the lead.

There are many refractory ores of complicated mineralogical character which might be reduced by smelting as well as by leaching or by amalgamating processes.

To assist mining men in selecting the process by which such ores may be best reduced we will describe the ores and works of the Gregory Mining Company, giving the cost and the result of the reductions, and consider the various ways in which the ore might be worked.

Gregory mines contain about,

Ten to twelve per cent of galena.

Eight per cent of arseno-pyrites.

Six to twelve per cent of iron and copper pyrites.

" " " " " zinc blende.

Sixty to sixty-five per cent of quartz.

A ton of the galena ore carries about twenty dollars of silver. A ton of the arseno-pyrites carries about fifteen dollars of gold.

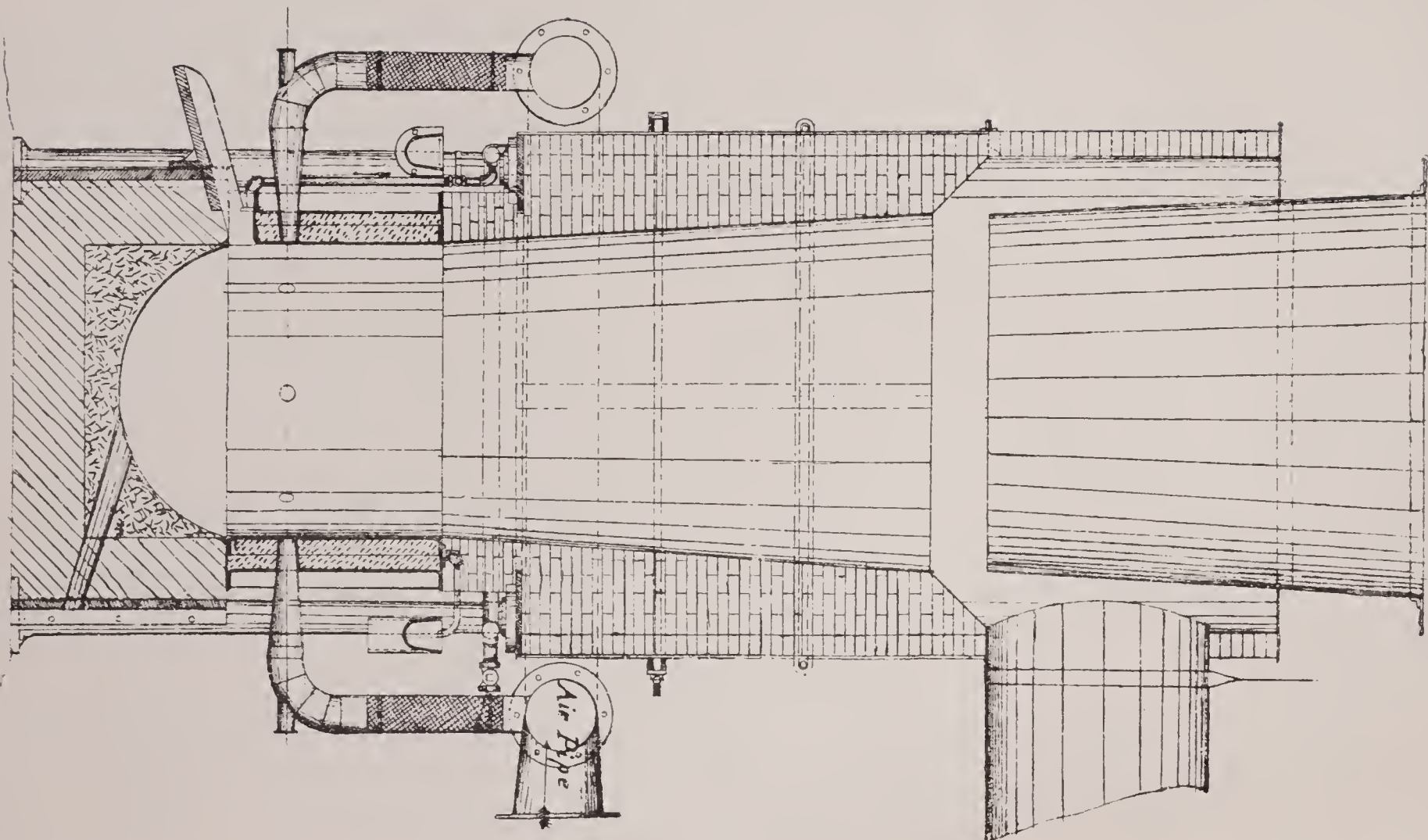
The iron and copper pyrites carry but a trace of gold and silver.

The zinc blende, and the quartz hold no valuable metals.

When running full capacity the Gregory Company reduce 100 tons of this refractory ore per day, producing copper matte and lead bullion carrying the precious metal.

The works consist of a concentrating mill having 150 tons capacity per day. Six reverberatory roasting furnaces. One Hesse smelting furnace.

To smelt the Gregory ore without previous concentration would not be possible, at least could not be made profitable, as nearly ninety per cent of the ore would have to be gotten rid of in the smelter, and as nearly an equal amount of flux would have to be added to the ore to make its reduction feasible.

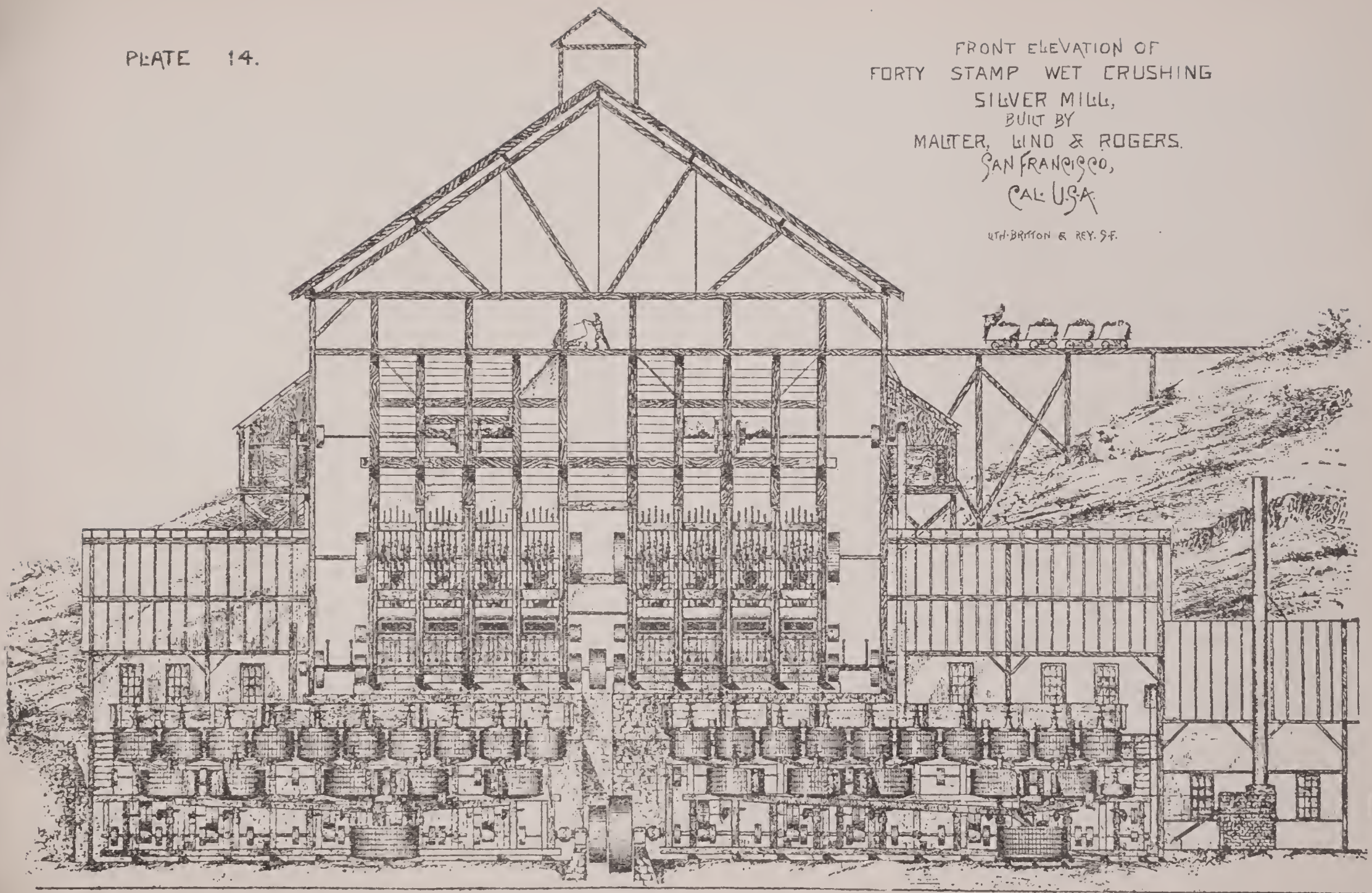


Sectional View of the Hesse Smelting Furnace

PLATE 14.

FRONT ELEVATION OF
FORTY STAMP WET CRUSHING
SILVER MILL,
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO,
CAL. U.S.A.

UTH-BRITTON & REY. S.F.



The fuel required to smelt this great amount of material would probably exceed the value contained in the ore.

The concentration of the ore greatly cheapens the subsequent extraction of the precious metal, although the ore be of a character difficult to be concentrated. The quartz of the Gregory ore is extremely hard, and the metal very finely divided through it, hence the ore must be crushed very fine to separate the metal from the gangue.

Fine crushing produces a large amount of slimes, even if the crushing is done by pressure in rigid rolls and breakers in which all grinding action is avoided. Slimes cannot be easily concentrated. They are separated by our slime separators from the coarser tailings and the finer quartz, and gathered in a reservoir, where they are permitted to settle; the clear water is then pumped back from the reservoirs to be used over and over again. If this water was permitted to run away, it would carry the slimes with it.

Owing to the difficulty of concentrating the Gregory ore, the company were compelled to discard their old concentrating mill with cornish rolls and Collum jigs, and to build new works of our construction and improved machinery, which thoroughly reduce the ores at a very small cost.

The Gregory Company have six reverberatory furnaces of the construction shown on page 35.

The capacity of each furnace is six tons of concentrates per day of twenty-four hours. The roasting is a *dead roasting*, and its cost is a little less than four dollars per ton of concentrates.

The revolving furnaces are not suitable for the purpose of dead roasting ores since much time is required, and hence much power would be expended in keeping the furnace in motion with its mass of ore, and a large percentage of the roasting ore would be raised as dust in consequence of the continuous action of the revolving furnace; this valuable dust would be carried into the dust chamber and perhaps out

of the chimney, it would at least be partly lost and probably insufficiently roasted for further working. With chloridizing roasting, it is otherwise, revolving furnaces do such roasting well enough, much less time being required to produce chlorides than oxides, and hence less motive power is consumed by the shorter work and less dust made.

Each furnace at the Gregory consumes daily two cords of wood, costing four dollars per cord; and four men are required to attend to them, two in day and two at night. About three hundred pounds of pulverized charcoal (sifted refuse) are added for each furnace charge, to prevent the formation of arseniates, and to prevent ore from adhering to the hearth.

The benefits derived from the *dead roasting* are:

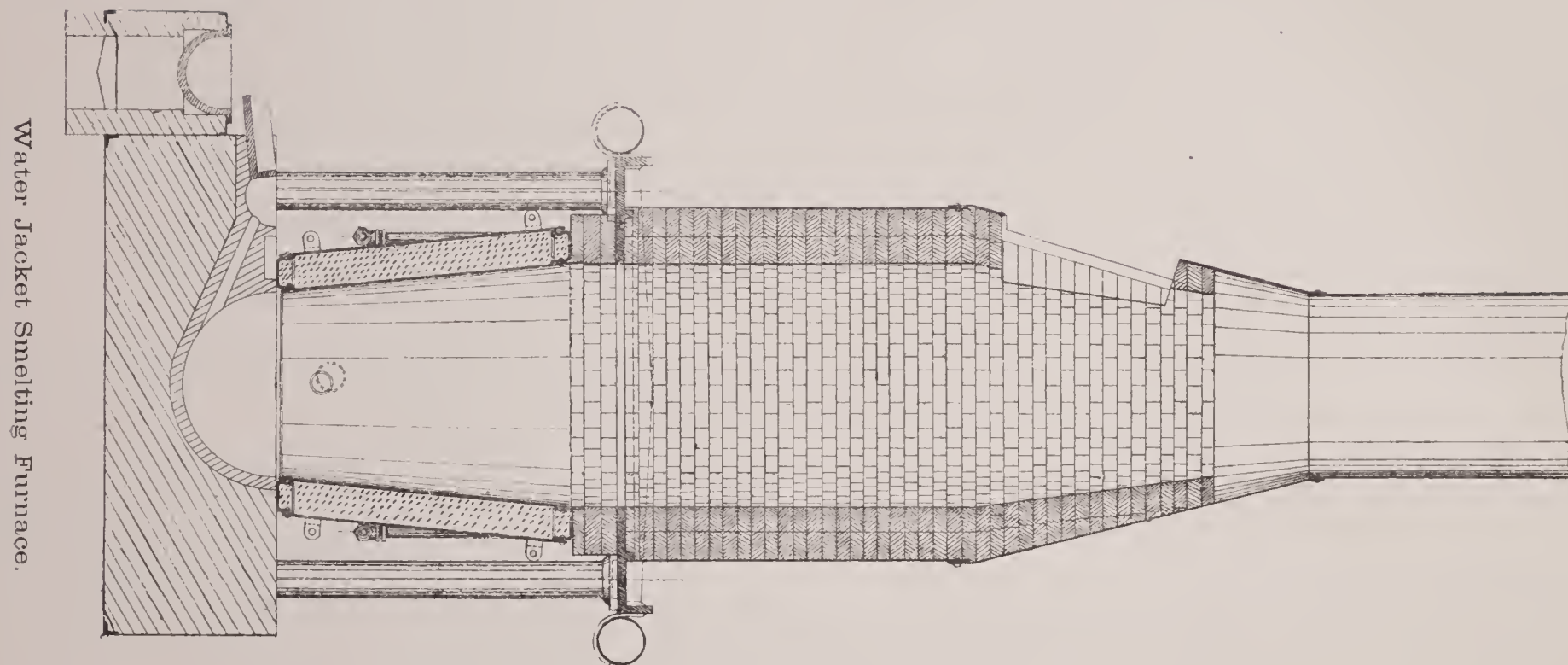
First.—Nearly all of the arsenic is expelled.

Second.—The galena is largely converted into oxides of lead.

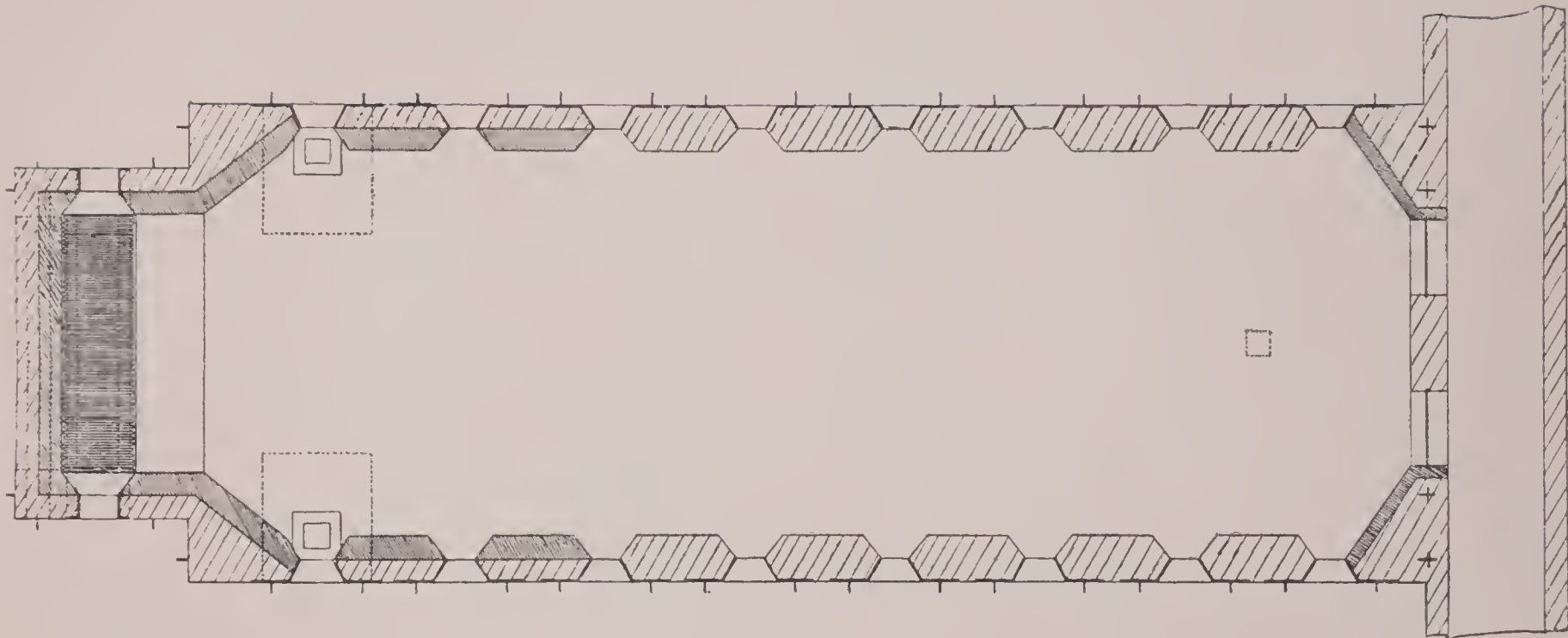
Third.—The iron and copper pyrites are reduced to oxides; the iron forms a flux for the quartz, and the copper makes a valuable matte.

If the ore were not roasted previous to being smelted, no metallic lead could be produced, and a good deal of very expensive iron and lime fluxing would be required, which becomes unnecessary after driving off the sulphur by roasting.

The Hesse furnace has a capacity for reducing daily from twenty-five to thirty tons of roasted concentrates, which yield seven to eight tons of bullion, and five per cent of copper matte. The cost of reduction is nine dollars per ton of concentrates, charcoal for smelting purposes being worth twenty-five cents per bushel, and coke, twenty dollars per ton.



Water Jacket Smelting Furnace.



Reverberatory Furnace.

1777
1778

The copper matte is crushed, roasted in kilns, and passed through the blast furnace two or three times with the concentrates until a high grade copper matte results. The bullion contains never less than ninety-five per cent of all the gold and silver which was in the concentrates; it is worth about four hundred and fifty dollars per ton. Assuming the ore to have been worth thirty-five dollars per ton in gold and silver, which is about its value outside of the lead, and reducing fifteen tons of ore to one ton of bullion worth four hundred and fifty dollars, it will be seen that seventy-five dollars have been lost out of the total value of the precious metal contained in fifteen tons. This is a loss of five dollars per ton in precious metal. And since the value of the lead enhances the value of the metal resulting from the working of 15 tons of ore and is included in the \$50 dollars, the loss per ton of ore by this process of working appears even more than five dollars per ton. However, the loss is not so great since the slimes contained in the reservoir are valuable, as is also the copper matte. The slimes are roasted, made in adobes, and smelted; the copper matte is saleable.

The entire cost of reduction of the ore sums up as follows:

Concentrating one ton of ore into 500 pounds of concentrates, costs \$1.

Roasting of one ton of concentrates costs approximately four dollars, there being *four tons* of ore reduced to one ton of concentrates makes cost for *one ton of ore* equal to \$1.

Smelting at cost of nine dollars per ton for *roasted concentrates* which equals two and one-half dollars per ton of ore (\$2.50), (10 per cent of weight being lost in roasting).

Total cost for working *one ton of ore* \$4.50.

THE ADVANTAGES AND DISADVANTAGES OF WORKING REBELLIOUS ORES BY VARIOUS PROCESSES.

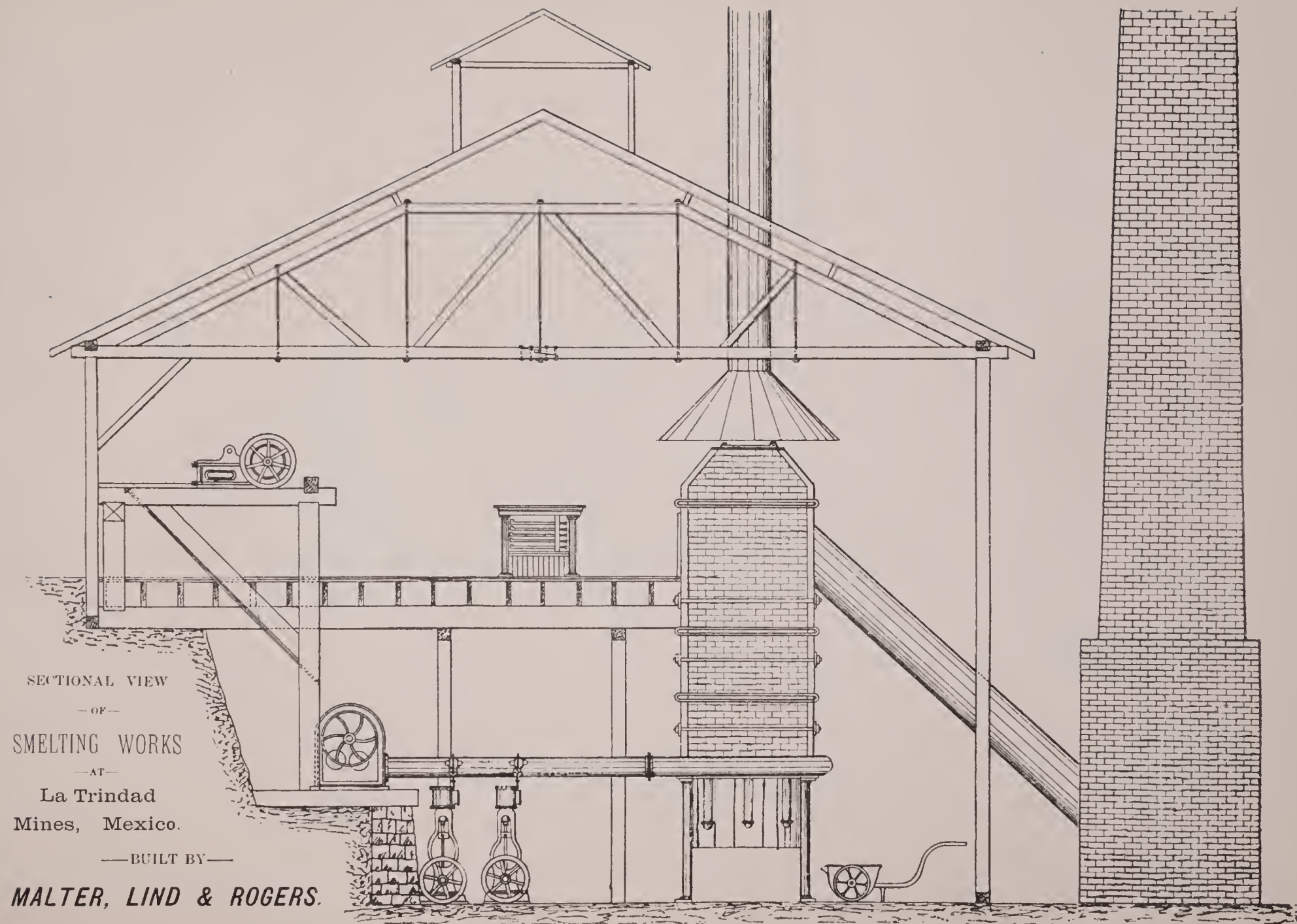
Although the Gregory ore contains a large amount of base metal, it might be worked by the dry-crushing mill and amalgamating process. Metallurgists have frequently undertaken to reduce equally refractory and base ores by that process.

The cost of working such ores by that process, would be about 15 dollars per ton. At least ten per cent of salt would be required for the chloridizing roasting, in order to convert both the precious and the base metals into chlorides, for the base metals must be either chloridized or oxidized before the precious metal, the silver, can be converted into chlorides.

It would probably be impossible to save any appreciable percentage of the gold by the amalgamation process after roasting the ore. *Gold does not generally amalgamate well if the ore has been previously roasted*, and since gold constitutes 40 per cent of the value of the ore, its loss if amalgamation prove insufficient, would make the working of the ore unprofitable.

To reduce one hundred tons of ore (as do the Gregory works) by dry-mill process, would require a sixty stamp-mill, the first cost of which is much more than the Gregory works.

The wear and tear, and the consequent cost of repairs and depreciation of value of the reduction plant, is twice as great in a Dry Crushing Mill as in a concentration and smelting works. All the value of lead and copper in the ore would be lost. The bullion resulting from the amalgamation process would contain but a small portion of it, and that in a manner which depreciates the value of the bullion rather than enhances it, lead and copper being an alloy with the silver.



SECTIONAL VIEW
— OF —
SMELTING WORKS
— AT —
La Trinidad
Mines, Mexico.
— BUILT BY —
MALTER, LIND & ROGERS.

The base metals might be leached off in part with water, after having been converted into chlorides by roasting, previous to amalgamation of the silver in the pans, but this would add expense in labor, and probably loss in silver. Chlorides of lead cannot be very well leached out of silver ores.

Considering the above disadvantages and difficulties, it is quite evident that ore of the value and character of the Gregory ores could not be reduced properly in a dry crushing and amalgamating mill.

It has frequently been undertaken to extract the precious metals from such ores as the Gregory, by lixiviation. The preparation of the ores for the lixiviation process, consists in crushing them finely in a dry crushing stamp battery as is done for the roasting and amalgamating process; then the ores are subjected to a chloridizing roasting, and afterwards put into leaching tanks where the silver is leached out by a solution of hyposulphates of soda or lime. The ore would then have to be dried and chlorinated to convert the gold in it into soluble condition, and to make possible its extraction by leaching.

This process, of course, is quite complicated, and in all probability, would not yield as high a percentage of the precious metal as the concentration and smelting process.

The cost of working the ore by leaching process, could not be less than ten dollars per ton if the ores were not concentrated before roasting and leaching. If concentrated the cost of the lixiviation process might not exceed the cost of the smelting process per ton of ore worked. The value of the base metals, lead and copper, would be lost in the leaching as well as in amalgamation. Dry crushing the ore finely in a stamp battery would cost more than crushing the ore coarsely in rolls and concentrating it.

The chloridizing roasting necessary to prepare the ore for the leaching operation could be effected in automatic furnaces, and would require less time than the dead roasting preparatory to smelting, but it would not cost any less since a large amount of salt would be required. Then the cost of leaching with water for base metals, and with hyposulphates for silver, and employing the chlorination process to extract the gold after drying the ore again, would certainly not be less expensive, than the mere smelting of the concentrated and roasted ore in a furnace.

The cost of the necessary reduction works for either leaching or smelting is about the same. The consumption of fuel is larger in the smelting process; the amount of labor required, greater in the leaching process. Considering this, it remains a question as to which process should receive the preference in working ores of the character of the Gregory ores.

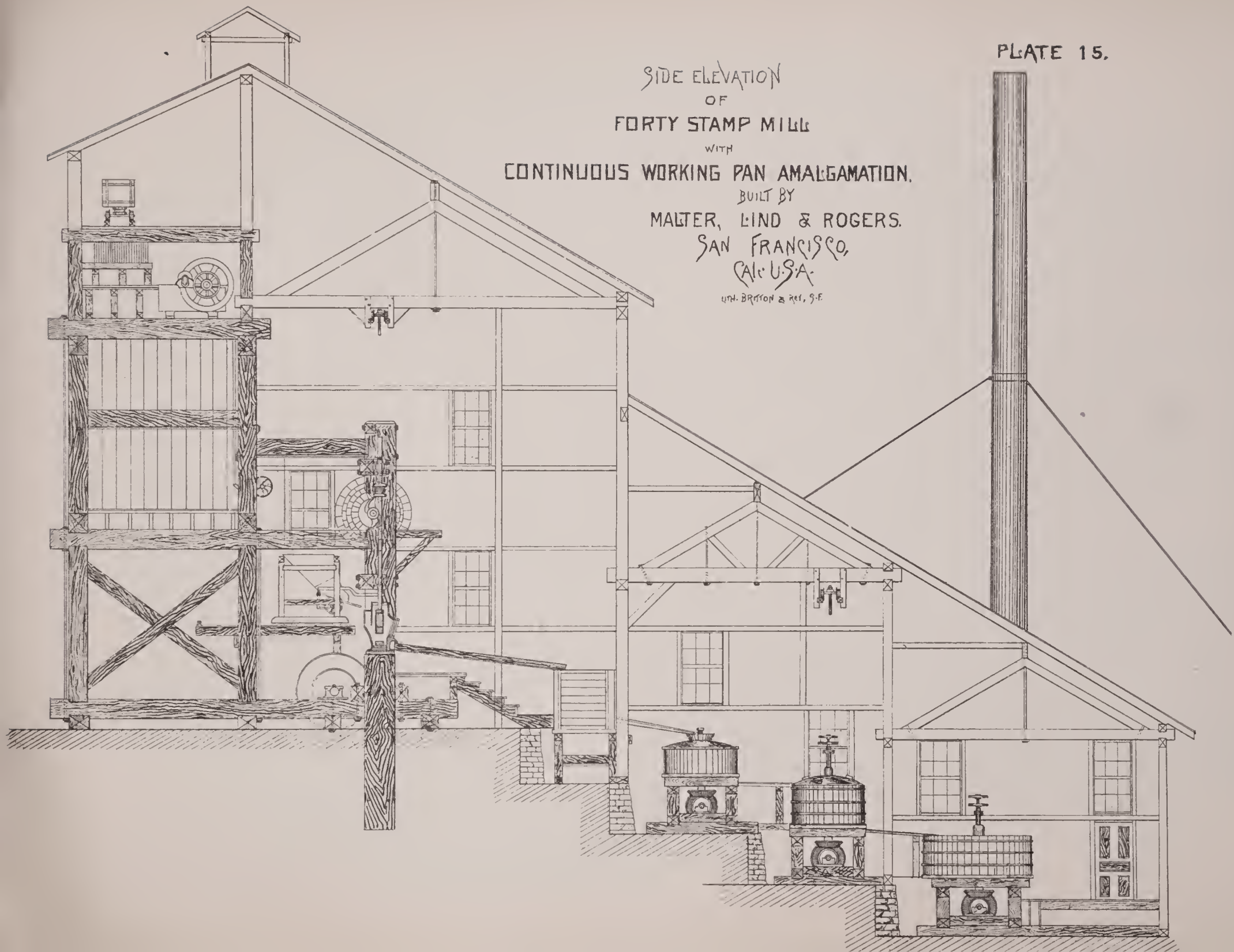
This question can only be answered after investigating the conditions of the country. Thus in Mexico, where labor is cheap and fuel expensive, leaching might be given the preference; in our northern mining regions, where fuel is found in plenty, and labor commands a high price, the smelting process might be more advantageous.

SIDE ELEVATION
OF
FORTY STAMP MILL
WITH
CONTINUOUS WORKING PAN AMALGAMATION.

BUILT BY
MALTER, LIND & ROGERS.

SAN FRANCISCO,
CALIF. U.S.A.

WITH BRITTON & REE, S.F.



THE LIXIVIATION OR LEACHING PROCESS.

Under this name is understood the extraction of chloride of silver from ores by alkaline hyposulphates, which method Percy and Hanch proposed in 1850.

Patera of Joachimsthal, Bohemia, 1858, was the first who applied the method in a practical way by using hyposulphate of soda as a solvent for the chloride of silver, and polysulphide of sodium as a precipitant, while Kiss, in Hungary, 1860, used hyposulphate of lime as solvent, and polysulphide of calcium as precipitant. Patera subjects the ore before leaching to a very complicated and expensive roasting.

In Kustel & Hoffman's Modified Leaching Process, which was first introduced by them at La Dura, Mexico, in 1868, the chloride of silver is dissolved in hypophosphate of soda and precipitated with polysulphide of calcium. This modification made the leaching process adaptable for our country and Mexico, and it is this modification which is so extensively used on this continent. The polysulphide of sodium, as well as the hyposulphate of lime are very troublesome to manufacture, while polysulphide of calcium is easily prepared (by boiling sulphur, water and lime), and the hyposulphate of soda can be bought cheaply in the market.

The advantage of Kustel's modification is proved by the fact that in none of our numerous leaching works is either the Patera nor the Kiss process used as such.

APPLICABILITY OF THE LEACHING PROCESS.

This process can be applied to much larger variety of ores than amalgamation, in fact most any kind of silver ore, no matter how base, *which permits a good chloridizing roasting and a good filtration is suitable to be worked by it.*

It is well to ascertain what percentage of silver can be chloridized in roasting, as only the chloride of silver can be

extracted by this method. This can be done by roasting one-half ounce of the ore with salt in the muffle. After the roasting is finished the ore is carefully put into a paper filter and leached with water, and then with hyposulphate of soda until all the chloride or silver is extracted. Then the tailings with the filter are placed in a roasting dish, dried and heated in the muffle to burn the filter, and finally fluxed in a crucible, and assayed.

Another one-half ounce of the same sample of raw ore has to be assayed from the difference of both results, the percentage of the chloridized silver can be calculated. This difference also tells us the approximately obtainable percentage of silver, less loss in roasting. Usually a better chlorination can be obtained by roasting on a large scale. Roasted ore filters much better than raw ore. If an ore contains a great deal of clay and is not too rich in silver, a slight concentration by which the clay is separated from the ore can be obtained from it.

The advantage of lixiviation consists in the cheapness of reduction, and the low cost of the plant. No power is required, except for crushing and roasting, and there is hardly any wear and tear, as the vats last many years; the wood being protected by the base metal chlorides from decaying. The most *favorable* feature of the process, however, is its applicability to very refractory ores. Of great advantage is also the fact, that there is no machinery used, no loss of time can occur in the leaching department of a mill on account of breakage. There is also no need of stopping the operations on account of "clean up's," as one precipitation tank after another can be cleaned up while the other tanks are working to their full capacity.

MANIPULATION.

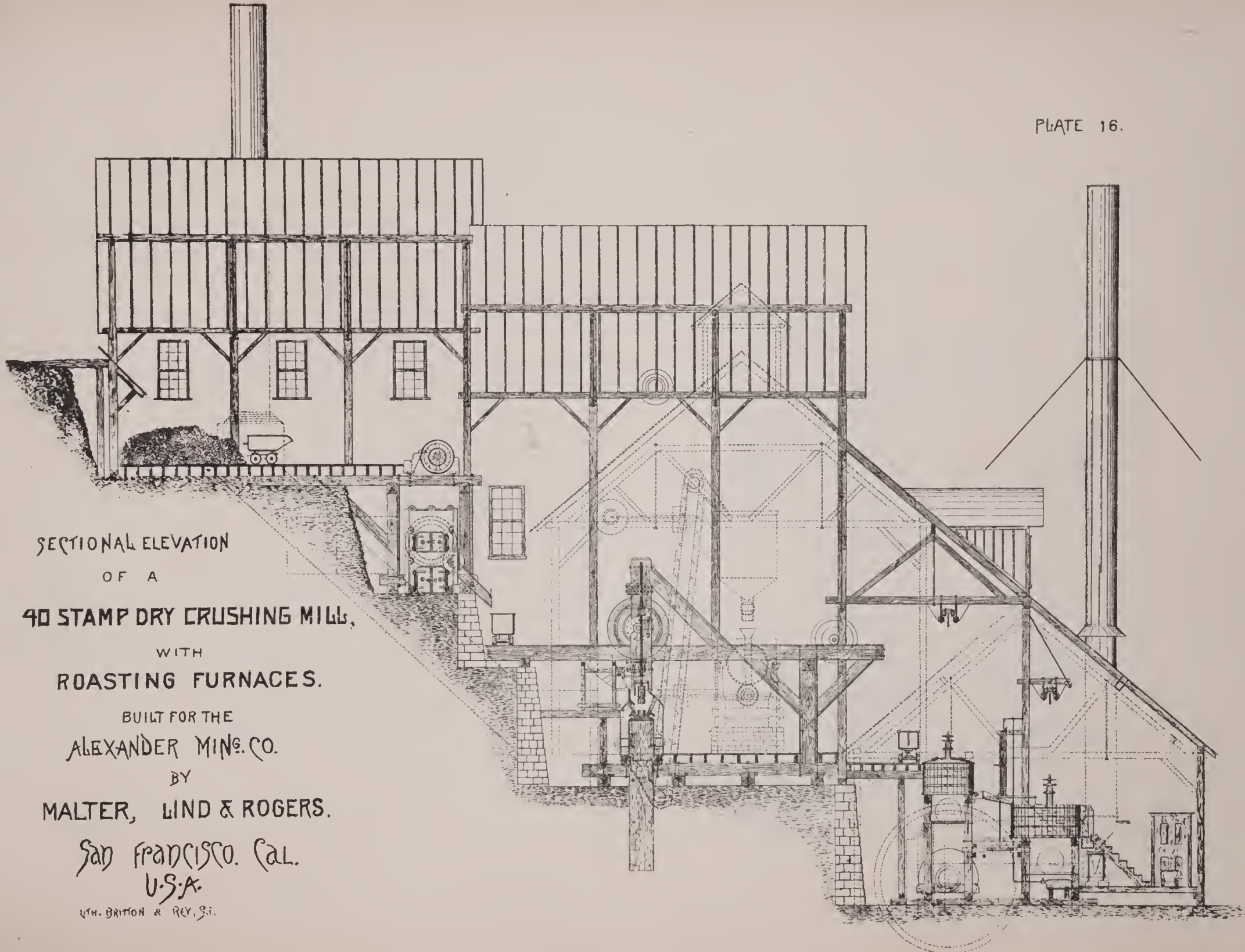
A—ROASTING.

If no concentration is required, the ore has to be crushed dry on account of the subsequent roasting, but only in exceptional cases is it necessary to pulverize through a finer screen than No. 40. Some easily roasted ores, especially those which are free or contain but a small percentage of zinc blende, will permit a good chloridizing roasting, even if pulverized through screen No. 20. Coarse pulp is preferable as it improves the filtering capacity of the ore, which shortens the time required for extraction. But the roasting has always to be the guide for the operator in selecting the proper fineness of the pulp.

In order to chloridize the silver, the ore has to be roasted with an addition of common salt. To roast successfully a sufficient quantity of sulphurets must be present in the ore, as the sulphurets by decomposition, produce sulphuric acid, which acts on the salt and liberates the chlorine necessary for the formation of silver chloride. The amount of salt to be added depends on the character of the ore, and varies between five and ten per cent. Rich ore requires more than poor ore: and again, if the same is highly sulphuretted, and very base, a higher percentage of salt has to be used. The proper amount is easily ascertained. In starting the works it is advisable to begin with a higher percentage of salt than the character of the ore would justify, and then to drop at each successive charge, one per cent, until the point is reached where the chlorination begins to suffer. An assay and chlorination test of each charge has to be made and the result put on record, which will enable the operator, without difficulty, to ascertain the necessary amount of salt.

The salt ought not to be coarser than the pulp, and should be well mixed with the same before charging the furnace. This is done either by crushing the ore and salt together, or better by crushing the salt separate and adding it continuously by means of a salt-feeding machine into the conveyor, where the screw will perform a very thorough mixing. By using continually discharging furnaces this previous mixing is a necessity, while with charge furnaces it has the advantages that, if lumps are formed in roasting, the same will be chloridized too, as the salt is divided through them. In cases where the ore bakes easily on a little increase of heat, it might be found advisable to add the salt after the formation of sulphates take place, but to do this, in order to diminish the loss of silver in roasting, is an operation which should be performed only if it is actually found to have the desired effect, as in most instances, no better result will be obtained by it, but on the contrary, will often be the cause of a lower chlorination, an increase of flue dust, and extra labor. This is not the case, however, if the oxidizing roasting is continued until all the base metals are converted into oxides and then the salt, and from one to three per cent of green vitriol is added. But this mode of roasting is more expensive on account of the additional use of green vitriol and the longer time required to effect oxidizing roasting.

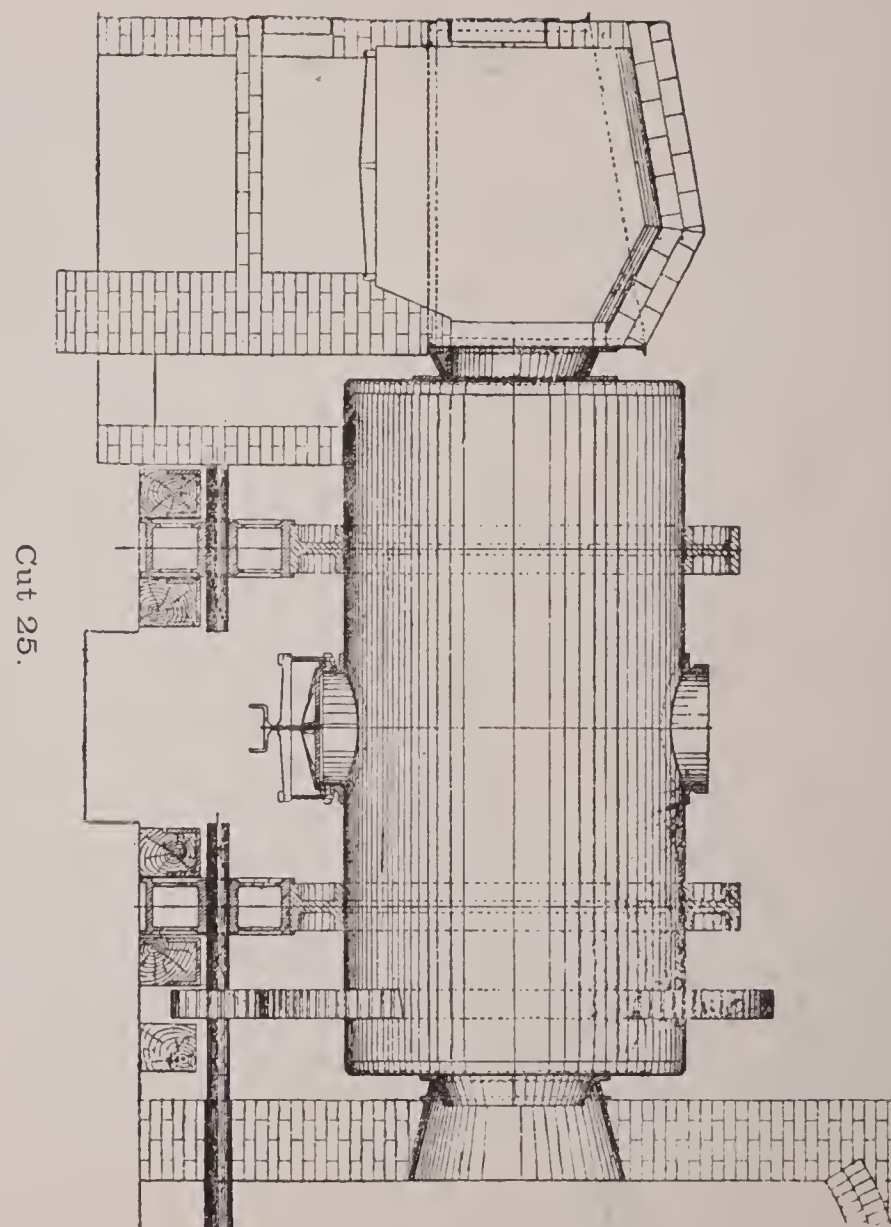
The mechanical furnaces, almost exclusively in use now, for chloridizing roasting are divided into two classes: *those with continual feed and discharge, and those which are fed by charges.* As the roasting is the most important part of the process, the part upon which principally depends the good result of the extraction of the silver: it is very important to select the right kind of furnace for a certain kind of ore, furnaces which are fed by charges like the improved Bruckner furnace, are more reliable, and can be used for any kind of silver ores, even the most rebellious, as the operator has the charges under his



SECTIONAL ELEVATION
OF A
40 STAMP DRY CRUSHING MILL,
WITH
ROASTING FURNACES.
BUILT FOR THE
ALEXANDER MINE CO.
BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL.
U.S.A.
LTH. BRITTON & REY, S.I.

perfect control, and can conduct the roasting according to the nature of the ore, while through a continually discharging furnace the ore passes in a certain given time and the operator has to accept the ore as the furnace gives it to him, whether the roasting is finished or not, for which reason this kind of furnace is applicable to the more easily roasted ores only.

Before charging, the furnace has to be made to revolve, and has to be well heated by a gradually increased fire. Then the charge doors are opened, and the furnace stopped with the doors beneath the hoppers. By pulling the slide of the hopper, the whole charge drops from it into the furnace. The doors quickly closed, the furnace is set in motion again and a strong fire kept up, until the sulphur commences to burn well, then the fire is slacked, or if the ore contains so much sulphurets that the burning of the sulphur creates too great a heat, the fire is stopped entirely, until a falling off of the temperature is perceived. Then the fire is started again, but the temperature is still kept moderate, until the reaction between the sulphates and salt begins, when the heat is increased to bright red, and kept so until the chlorination is finished. During the oxidizing period, the formation of sulphates takes place. Strong fumes of sulphurous acid, and, if present, of antimony and arsenic are evolving from the ore, the ore retaining a sandy appearance. As soon as the reaction of sulphate and salt commences, the ore increases in volume, assumes a woolly consistency, and, while the smell of sulphurous acid disappears, that of chlorine is taking its place.



quired. This pipe is called the air valve, and permits the escape of air from under the filter.

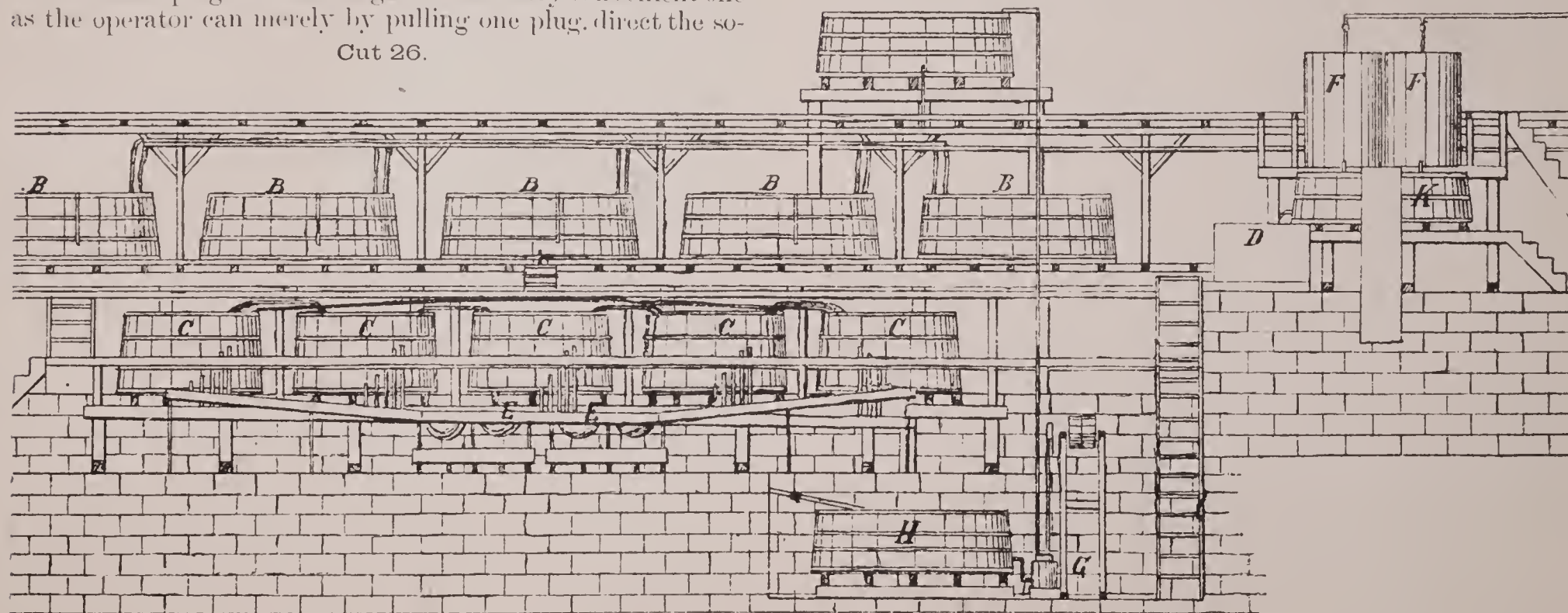
This is of great service, as it prevents the air from breaking holes in the filter, by ascending through the ore. Along the front of the leaching tanks, and about 24 inches lower, extends a gallery four feet wide. On this floor, and about the middle of the whole length is placed the distributing tub I. It is a flat tub of about 20 to 30 inches diameter, and 12 inches in depth. Into this tub is conveyed by means of two troughs the silver solution of all the leaching tanks. The bottom of the distribution tub is provided with as many lead pipe outlets, as there are precipitation tanks. Each outlet can be closed with a plug. This arrangement is a very convenient one as the operator can merely by pulling one plug, direct the so-

Cut 26.

lution to flow into either of the precipitation tanks C C. Another trough along the tanks conveys the base metal solution. In front of the leaching tubs are the precipitation tanks and placed in such a way, that the upper rim comes about 18 inches below the platform, extending about two feet under the same. It is well to have about four or five of these tanks, in order to give the precipitated silver plenty time to settle.

Another gallery (not the precipitating floor) is located about two feet below the top of these tanks.

The sulphide of calcium solution is conveyed by means of hose from the reservoir to each tank. The flow of the solution can be regulated by hose clamps.



The next lower floor is the filtering floor, which is placed about 3 feet, 6 inches below the bottom of the precipitation tanks. The part of the tanks which reaches below the precipitating floor is provided with one outlet close to the bottom for the discharge of the silver, and from three to four others in different levels for decanting the clear solution. These outlets are also provided with hose and clamp, and discharge into a trough leading to the pump tank or lower reservoir. The filters E E consist of one or more square frames, each of which is divided into four squares 3 feet by 3 feet, and covered with unbleached cloth, forming in each square a filter sack. They are constructed in such a way that the dividing scantling between the two filters is provided with a cut eighteen inches long and one and one-half inches deep, permitting the precipitate, if one filter is full to flow into the next, and so on until a whole set is filled. Each set of filters is suspended by frame-work above a square flat tank about ten inches deep, into which the filtrate runs, and from there it is conveyed to the pump tank H.

The material of the tank ought to be two and a half or three inches thick: clear lumber for staves and bottoms. In dry climates the troughs have to be lined with sheet iron.

2nd.—Base metal leaching:

After the leaching tank is charged the outlet hose is placed into the base metal trough and a stream of cold water is allowed to flow on the top, which in passing through the ore, dissolves the base metal chlorides. In the beginning the out-flowing water is highly charged with base metal salts. If there is considerable copper in the ore, the color will be green, and if there is lead and antimony, it will have a milky appearance from fine flakes of chloride of lead and antimony, and some silver. This is mostly observed soon after the first concentrated liquid has passed off, and the solution becomes less concentrated, or, if the concentrated liquid mixes in the base metal trough with a stream of diluted base metal solu-

tion coming from another tank. In leaching with water, the chlorides of iron, copper, zinc, lead, and antimony are removed. These chloride salts, if concentrated, have the property of dissolving chloride of silver, which, however, is precipitated again together with lead and antimony as soon as the solution is diluted.

As mentioned above, the first water from the base metal leaching is highly charged with these salts, and consequently some chloride of silver will be dissolved by them, but as the discharge of the concentrated liquid lasts only a short time, the amount of the dissolved silver is small and can easily be regained. Mr. Hoffman prevents the escape of this silver by admitting the stream of water from below, under the false bottom, instead of from above. By pressure, the water is forced to ascend through the ore, and the concentrated solution appears on top of the ore. Here the solution is diluted by a stream of water, and the precipitation of the chloride of silver effected. The liquid is now permitted to descend through the filter, and the chloride of silver remains on and through the ore, and is afterwards extracted with the balance of the silver.

Mr. Stedefelt, in making chlorination tests, made the observation that, if the sample of roasted ore is leached first with water and then with hyposulphide of soda, the result would show a higher chlorination than that obtained by leaching only with hyposulphide of soda without previous leaching with water. Both observations indicate that considerable chlorination takes place during the short time that the base metal is leaching.

The copper can be obtained from the chloride solution by precipitating the same with metallic iron, as copper cement, or by using as a precipitant, the iron sponge; a finely divided iron obtained by heating pulverized iron ore with charcoal powder in an iron retort.

The base metal leaching takes from one to two hours. If after adding a few drops of sulphide of calcium to a sample of the chloride liquid, only a reddish brown color appears, and no precipitate is formed: even if vigorously stirred, the leaching with water is finished, and the inflow of water on the top of the ore stopped.

At the Silver King Mine, Arizona, the silver carried off by the base metals was regained by conveying the concentrated solution to large tanks, and diluting the same with water, the chloride of silver together with the chlorides of lead and antimony precipitated and settled to the bottom. The clear solution was drawn off and the tanks charged again till enough precipitate is accumulated, when the same is strained, dried, and melted together, or with the silver precipitate in a cupelling furnace.

Mr. Kustel used for this purpose, at Flint, Idaho, a large flat box provided with partitions 6 inches apart, in such a way as to form a zig-zag trough, which was filled with shavings. Through this trough the chloride solution was permitted to flow after being diluted with a small stream of water. The shavings afford a large amount of surface for the chlorides to deposit on. The accumulated white precipitate he placed in filtering bags, washed it with water, and extracted the silver with hyposulphide of soda.

It seems that a part of the silver which escapes chlorination in the furnace is chloridized by action of the base metal chlorides during the process of leaching with water, especially if chloride of copper is present. Mr. Hoffman, by working the Silver King ore, found by taking samples just before the base metal leaching commenced, and after it was concluded, that during this process, the original chlorination of the already moistened ore improved from three to seven per cent. As a matter of course, the loss in weight which the ore sustains by removing the base metals had been taken into consideration.

3rd.—Silver Leaching:

As soon as the water disappears from the top of the ore a stream of a diluted solution of hyposulphide of soda is conveyed into the tank. It is not good to let the water drain entirely from the ore before the hyposulphide of soda is let in, as in this case, air is sucked into the charge, which afterwards, partly by ascending breaks little channels in the ore, through which the solution runs more swiftly than through other places, and partly remains in the ore, forming little bubbles, thus preventing the solution from coming in uniform contact with all the ore particles.

If done as described here, the stream of water from under the filter will flow undiminished, and is still permitted to flow into the base metal trough, but close watch has to be kept, and the liquid frequently examined, if it contains silver. This is done by adding a few drops of sulphide of calcium to a sample of the solution. As soon as the least indication of the formation of dark clouds are perceptible, the solution contains silver, and the outlet hose has to be placed in the silver trough. The presence of silver is indicated too, by a sweetish taste in the solution. It takes about fifteen to twenty minutes before the silver solution begins to run out, but it becomes in a short time highly charged with silver. Sulphide of calcium added to the solution causes a heavy dark brown precipitate. In a few hours the main part of the silver is leached out. The precipitate is now of a more reddish brown color, and not as thick and heavy, but still carries silver. It contains principally lead and copper. By conveying the concentrated and the diluted solution to different tanks and treating them separately, two kinds of bullion can be obtained if so desired, one very fine, and the other very base. This, however, is not usually done.

In roasting, part of the lead remains in the ore as sulphate and part of the copper, as subchloride. These base metals are not soluble in water, but are so in a solution of hyposulphide of soda, and dissolve more readily in a concentrated solution than in a diluted one, therefore, it is well to use a diluted solution of about 1-2 to 1. Two pounds of hyposulphide of soda, is capable of dissolving one pound of silver.

Chloride of lime dissolves more easily than the sulphate of lead, and the subchlorides of the base metals, consequently, after the soluble silver has been extracted, the solution still shows, in most cases, a reddish precipitate, caused by the presence of base metals, if sulphide of calcium is added. This reddish silver is extracted, and it is impossible for the operator to tell by looking at it, when all the silver is extracted, and he either does not leach long enough, or too long. This either causes a loss of silver, or a loss of time, and in the latter case, a great deal of base is unnecessarily added to the silver precipitate.

In order to avoid all this, and to enable the operator to know the exact time when the leaching should stop, Mr. Hoffinan introduced the following very simple and quick test:

A tumblerful or two of the solution is precipitated with sulphide of calcium. The precipitate is allowed to settle, the clear solution decanted, and the precipitate with part of the solution poured into a small paper filter. After all the solution has dropped through, the precipitate is washed with warm water: then the filter is taken out of the glass funnel and spread out. The precipitate is scraped off with the blade of a pocket knife, and introduced into a test tube. Some nitric acid is added, and boiled till no more red fumes escape. Then the tube is held in cold water to hasten the settling of the sulphur. The clear acid is carefully poured off from the sulphur into another clean test tube, and a few drops of salt water or muriatic acid are added. If a white

precipitate is formed, water is added and boiled to dissolve chloride of lead.

If the white precipitate remain, or if the solution retain a milky appearance, it is proof that there is still some soluble silver left in the ore, and the leaching has to be continued. On the other hand, if by the addition of salt water no precipitate was formed, or if the white precipitate dissolved by boiling with water, no more soluble silver is contained in the ore, and the leaching is finished and can be stopped. It is important in the above test, to wash the precipitate with water before dissolving the same in nitric acid, as Mr. Hoffinan found that in the presence of alkaline hyposulphides, only a partial precipitation takes place with chloride of sodium or none at all, if only small quantities of silver are dissolved in nitric acid.

The time required for the extraction of silver, varies from 8 to 20 hours, and depends upon the amount of silver contained in the ore, and the leaching capacity of the same. The silver from good filtering ore is more quickly extracted than from a slow filtering ore.

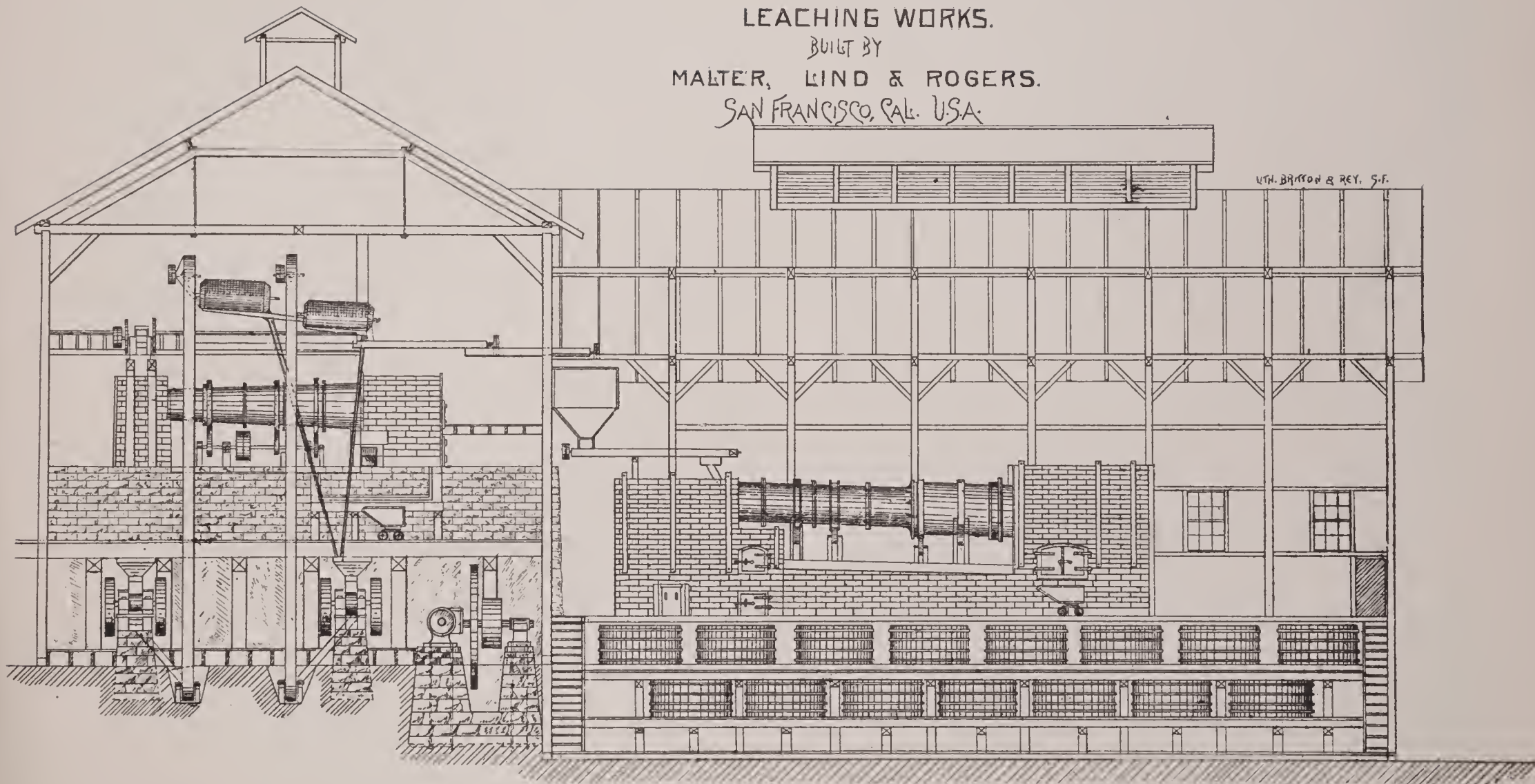
Lumps formed in roasting, are not injurious. Mr. Hoffinan found that as long as they had a porous consistency, and provided the salt had been fixed in the ore before charging in the furnace, the extraction of silver was just as perfect as that from the fine part of the ore. It is, however, different if the lumps are very hard and clinker-like and have lost their absorbing power.

For reasons given above, the tailings from the tanks, after a well conducted livivation, will be found to be poorer than those obtained in the chlorination test of a sample taken from the furnace at the time of discharge. If a charge had been roasted to 85 or 87 per cent chlorination, the tailings of the vats will show that there had been an extraction from 87 to 90 per cent of chloride of silver. The loss in weight which the ore sustains during leaching, has of course, to be brought

FRONT ELEVATION
OF
LEACHING WORKS.
BUILT BY
MALTER, LIND & ROGERS.
SAN FRANCISCO, CAL. U.S.A.

PLATE 18.

LITH. BRAYTON & REY, S.F.



into consideration. This loss in weight depends on the nature of the ore, and varies from 5 to 15, and more per cent, and consequently, a corresponding percentage should be deducted from the value of the vat tailings.

After the silver leaching is concluded, the tailings left in the tank contain a considerable solution of hyposulphide of soda, which has to be displaced by water turned over on the tailings.

It was mentioned above that as soon as the solution showed signs of silver, the outlet hose is placed from the base metal through into the silver trough. The solution now runs into the distributing vat, thence by pulling out the first plug, it flows into the first precipitation tank. If the first tank is filled to about 12 inches below the rim, the first plug is replaced, and the second opened, and the solution made to fill the second tank, and so on.

PRECIPITATION.

As soon as one tank is filled with the silver solution, the operator commences with the precipitation. He opens slightly the clamp valve of the hose, which furnishes the supply of sulphide of calcium, and throws a little of the chemical on the solution, by moving the hose once or twice over the surface. This is done in order to see whether the solution is concentrated in silver or not, and serves as preliminary test. If the solution is found to be very rich, the hose is placed over the rim of the tank, the clamp valve opened wide, and a full stream of sulphide of calcium flows into the silver solution. At the same time, a vigorous stirring has to be maintained. The full stream of sulphide of calcium is allowed to run in, till the scum formed by the stream becomes light yellow. Then the valve is closed, but the stirring continued for a short time, when the precipitate is allowed to settle a few inches, and the second test is made by throwing some of the chemical, with the hose, on the surface. The clouds which

form now, will be lighter in color and lighter in weight. A small stream of sulphide of calcium is now kept in, and the agitation continued till white clouds commence to appear, then the inflow of the chemical is stopped again, and after the precipitate has settled a few inches, the test with the sulphide of calcium is repeated. If no more colored clouds appear, the precipitation is finished, and after a good stirring the precipitate is allowed to settle to the bottom of the tank. By conducting the precipitation as described, the same can be performed much more quickly than by taking samples with a glass, and testing the solution outside the tank. It is well to make the check test after the main part of the silver has settled, and the solution become tolerable clear, by throwing a tumblerful of concentrated solution of silver over the surface flat. If it colors, it indicates a surplus of sulphide of calcium and solution has to be added until no more reaction takes place.

The tank is left undisturbed until the silver solution is turned into the last precipitation tank, by which time all the precipitate has accumulated on the bottom, and the solution become perfectly clear, then it is drawn off by opening the the different outlet valves, with the exception of the lowest one. In case of need, this decanting can be done three-quarters of an hour after precipitation. As by the agitation of the stirrer, considerable precipitate finds its way into the outlet hose, a bucketful of each has to be drawn off first before letting the solution run into the discharge trough which leads to the pump tank. The solution in the bucket contains precipitate, and is poured into the filters. By precipitating the silver with sulphide of calcium the solution regains its solving property, and can be kept in constant use for quite a long time. Mr. Hoffman used the same solution which he prepared when starting the Silver King Leaching Works for more than a year and a half, at a production of nearly \$3,000 in bullion per day.

The decanted solution flows into the pump tank, whence it is elevated by means of a pulsometer or any other suitable pump, to the reservoirs which are placed about ten feet above the ore tanks.

TREATMENT OF THE PRECIPITATE.

When enough precipitation has accumulated and the clear solution has been removed, the lowest outlet hose of the precipitation tank is placed either directly over the rim of one of the filters, or into a trough which leads to the filters, the clamp valve is opened and the contents of the tank well stirred. After the first filter is full the precipitate will flow into the next and so on until the whole charge is in the filters. This arrangement of filters is very convenient as it saves much handling of so valuable a substance, and does not require much attention. In about three quarters of an hour the main part of the solution will have passed through the filter, leaving the precipitate in a muddy condition. The filters are now filled with hot water by means of a hose, and the precipitate well worked with a round pointed wooden spatula. The hot water passes through the filter still quicker than the solution. The precipitate is piled in the center of the filter in cone shape, and left to drain for two or three hours.

At Melrose, the silver precipitate was drained and dried in a centrifugal machine, with excellent results, in a very short time. A larger centrifugal had been made for the Silver King Mine, but the machine not having been well balanced, and the shaft being made too light, the use of the same had to be abandoned. So far, no further experiments have been made with the centrifugal, which, doubtless before long, will take the place of the filters.

Without previous drying or pressing, the precipitate is removed from the filters and recharged into a small reverberatory furnace where it is dried, and the major part of the

sulphur burned off. Instead of a reverberatory furnace, retorts can be used, and by distillation part of the sulphur regained. But this operation requires more fuel. If the burnt precipitate does not contain too much lead it will be partly covered with fine wires of metallic silver.

In smaller works the precipitate is melted with iron and borax in crucibles, the products of which are bullion, matte and slag. The matte is very rich, and has to go back to the battery and is treated with the ore. The bullion is, according to the nature of the ore, and the more or less perfect roasting is from 800 to 975 fine.

In larger works the crucible smelting is too tedious and expensive, and is the best performed with lead in a cupelling furnace.

At the Silver King Mine, the precipitate was melted in a German cupelling furnace, in lots of 2000 to 3000 pounds, and obtained, after eight to ten hours, silver bullion 995 fine, at a consumption of one to one and one-half cords of wood. The hearth was composed of a mixture of linerock and clay. The silver was dipped with ladles and poured into moulds.

The ore of the silver King is very refractory, consisting of large quantities of rich zinc blende, antimonious fahl-ore, peacock copper ore, galena, copper pyrites, iron pyrites, silver copper glance, and native silver. The latter was so prominent that almost half of the assay value of the ore was caused by native silver. The zinc blende is prominent. The gangue consists of heavy spar, some quartz and porphyry. The poorer ore, with porphyry gangue was concentrated, and the concentrates mixed with the sparry ore and worked by lixiviation. The ore was roasted in a revolving furnace. During 1881 the mixture of ore and concentrates contained an average, according to 1100 assays, of \$196.92; the average chlorination during the same period, was 94 per cent, while the actual extraction amounted to 69.02 per cent.

There was a loss of 6 per cent in the tailings, and of 4.8 per cent caused by roasting, dusting, and other sources of loss. During the same year 42,000 pounds of fine silver had been produced at a consumption of 43,148 pounds of sulphur, or about one pound of sulphur consumed to the pound of fine silver produced: it takes twice this amount of lime.

If the ore contains gold, the silver bullion will always contain gold too.

After a chloridizing roasting, some of the gold will be in the ore as sub-chloride, which does not dissolve in water, but does so in the solution, and is precipitated in the silver. If proper attention is paid, and the ore allowed to cool slowly after discharging from the furnace, much of the gold can be extracted by this process. From the concentrations of the Advance Mine, California, which contained \$250 in silver and \$25 in gold per ton, by simple leaching, 85 per cent of the gold was extracted. But such favorable results cannot be obtained from ores which are rich in gold and in which the value of the silver does not predominate greatly. Auriferous silver ores can be successfully treated by this method.

SULPHIDE OF CALCIUM.

This chemical used as a precipitant for the silver, is prepared by boiling two parts of lime and one part of sulphur with water: if the lime is not of a good quality or not fresh, more lime has to be taken in proportion. The boiling is usually done in wooden tubs, by inserting steam, but it is not possible to keep them tight: as after a short time the chemical will find its way through joints and pores and keep dropping. Round tanks made of boiler iron 6 feet deep and 4 feet in diameter, are far better. Two tanks placed close together on a platform, in each is inserted a $\frac{3}{4}$ inch steam pipe extending to about 10 inches above the bottom. The bottom inside is covered with 2-inch

planks to protect it from the poking with the stirring pole. Close to the wooden bottom each tank is provided with a 4 inch discharge pipe which is closed with a wooden plug. These two discharge pipes project over a flat wooden tank 18 inches deep, and 8 feet in diameter which is provided with a filter bottom. In front, or to one side of this tank is placed a square tank 6' by 6', by 2' deep so that the rim is lower than the bottom of the former tank. The square tank is also made of boiler iron, and serves to receive the manufactured solution of sulphide of calcium. An iron pipe leads down from it to the precipitation tanks.

Water and lime are charged first into the boiler and steam turned on while the sulphur is sifted in when the water boils. The boiling has to continue during four hours: then cold water is added to the liquid to cool it, and the sediment allowed to settle. The clear solution is drawn off by means of a syphon into the square iron tank; the boiler is filled again with water: some more lime and sulphur added and another boiling made. after the clear solution of the second boiling has been drawn into the same tank as that for the first boiling, the sediment is discharged into the filtering tank: the filtrate of the sediment flows also into the square tank.

A boiler tank of above dimensions may be charged with 400 pounds of lime of good quality, then the tank is filled with water to about 12 inches below the rim, 200 pounds of sulphur added, and the whole boiled for four hours: after the boiling is finished cold water is added to fill the tank to about 8 inches from the top. For the second boiling 70 pounds of lime is taken, and 35 pounds of sulphur, and the same amount of water. In the first boiling is obtained a solution of 9 to 10°B, in the second, 7 to 8°B.

Concentration and Ore Dressing.

There are many valuable mines the ores of which, in their natural state, are either too rebellious or low grade for successful and profitable reduction in the smelting furnace, the amalgamating mill, or in leaching works. These ores must first be subjected to the preparatory process of concentrating and dressing.

Concentration serves to separate the valuable metal contained in the ore, from part of its worthless gangue; dressing aims to separate the various components of an ore with a view of not only of reducing the bulk, but also of eliminating such portions of the ore which may be injurious and detrimental to subsequent working. Thus for instance, many of our argentiferous galena ores carry zinc blende which is usually poor in silver and very injurious in the smelting furnace, because of its inclination to carry silver into the slag or out of the chimney, if volatilization occurs. Galena and zinc blende may be easily separated from each other in most cases by the ordinary methods of ore dressing, the former being much heavier than the latter, and of different crystalline structure, thus, loss of silver in smelting may be avoided and the zinc blende may be obtained by itself almost free from lead, in which state it can be utilized profitably for the preparation of zinc white.

Among the ores which might be profitably prepared by dressing for subsequent working, are the following, the most common:

1. Ores containing a large percentage of lead, especially carbonate of lead, clay, talc, or talcose slate, out of which the silver is to be extracted by amalgamation: these substances interfere with the amalgamation, causing loss of the precious metal.

2. Silver ores containing antimony, cannot be well treated by the amalgamation process: if roasted, volatilization is apt to carry off a large percentage of the silver, if amalgamated

without roasting, the antimony will probably enter the amalgam making the quicksilver unfit to amalgamate with the silver, and thereby causing loss.

3. Copper ores containing lead, arsenic, or iron (other than spathic iron).

4. Tin ores containing iron, copper or arseno-pyrites, and zinc blende.

5. All lead and copper ores which are to be smelted, and the gangue of which does not make a favorable slag without expensive fluxing.

6. Auriferous pyrites containing talc, if the gold is to be extracted by the chlorination process, talc absorbs the chlorine gas; roasting the ore with much salt might overcome the difficulty; it might also cause loss of gold in roasting.

The desirability of preparing ores by concentrating or dressing for the extraction of the precious metal, is purely an economic question. If the preparation of the ore costs more than the saving effected in its final reduction, then such preparation would not be desirable.

The question of desirability of concentrating or dressing an ore, is easily determined in any particular case, if the cost of concentration is known. For the purpose of determining this question, the cost of the dressing may be roughly set down at from 50 cents to one dollar per ton of ore, depending on hardness of the ore, cost of fuel and labor.

The feasibility of the concentrating or dressing ore depends upon the specific gravity of its components upon its crystalline structure, and its chemical combination; it cannot be determined in any other way than by experiment; the sample to be experimented on should be large, and should be carefully taken from the mine, to represent a true average character of ore to be worked.

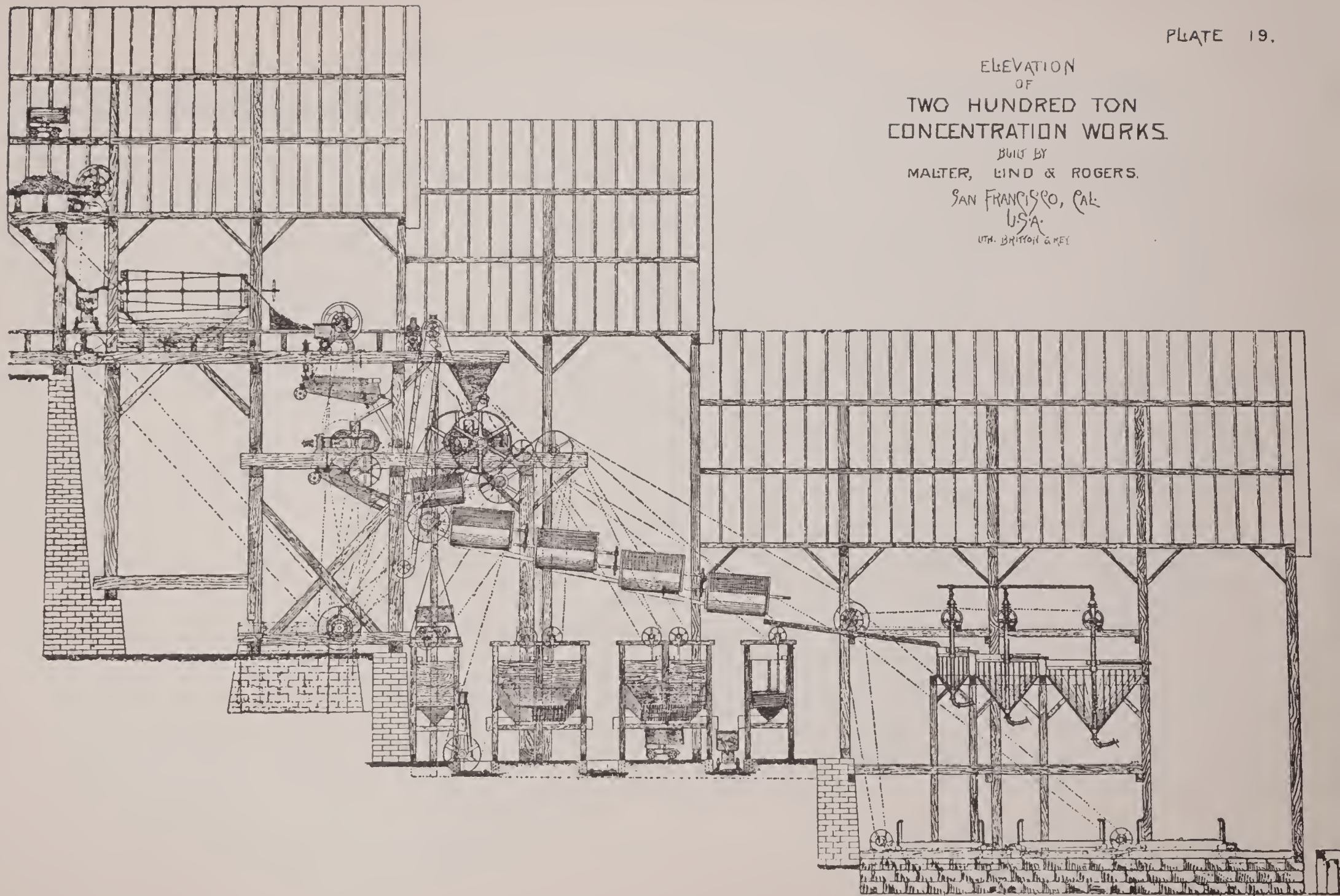
The ores best suited for concentration or dressing are those in which the various metals form separate crystals of favorable shape and size, and differing widely in specific gravity

ELEVATION
OF
TWO HUNDRED TON
CONCENTRATION WORKS.

BUILT BY
MALTER, LIND & ROGERS.

SAN FRANCISCO, CAL.
U.S.A.

WM. BRITTON & KEY



CONCENTRATION WORKS
OF
TWO HUNDRED TONS DAILY CAPACITY.

PLATE 19

Shows the side elevation of Two Hundred-Ton Concentrating Works for treating silver ores, which we have lately constructed for the Silver Queen Mining Company at Los Bronces, Sonora, Mexico. The ore is crushed first in large or coarse Rock-breakers, and after passing through the washing and hand-picking process, it is re-crushed in fine Breakers and coarse crushing Rolls, and separated in various sizes by screening. After *sizing* it by revolving screens, provided for the purpose, the coarser portions are again passed through fine crushing Rolls to be re-crushed and then re-sized. The various sizes of ore pass to the jigs, and from them to the Tailing Separators described on page 23. The Tailing Separators supply the slime jigs and percussion tables, which completes the operation in this Mill. The concentrates are leached in separate works to obtain the precious metals.

among themselves and with their gangue. Of course, metals which are in alloy with each other cannot be separated by dressing.

Ores containing iron, copper, or arsenical pyrites are easily concentrated in most cases: gray copper, brittle and ruby silver and sulphides of silver, as contained in most ores, are less easily separated.

Decomposed ores are apt to be reduced largely to so-called slimes during process of reduction, and for that reason are often unsuited for concentration.

The following is a table of the specific gravity of various metals and components of ore:

SPECIFIC GRAVITY OF METALS AND MINERALS.

METALS.	
Gold.....	19.25
Mercury.....	13.26
Lead.....	11.35
Silver.....	10.45
Copper.....	8.89
Iron.....	7.78
Tin.....	7.30
Zinc.....	7.

SPECIFIC GRAVITY OF MINERALS ASSOCIATED WITH ORES.

Hornblende.....	2.8 to 3.2
Syenite.....	2.7 to 3.
Trap or Basalt.....	2.8 to 3.2
Porpoerytrachyte or Felspar.....	2.3 to 2.7
Granite or Gneiss.....	2.4 to 2.7
Micaceous Slate.....	2.6 to 2.9
Clayey Slate.....	2.6
Limestone and Dolomite.....	2.5 to 2.9
Sand Stone.....	2.4 to 2.7

COMPARATIVE HARDNESS AND SPECIFIC GRAVITY OF ORES.

LEAD.	HARDNESS.	SPECIFIC GRAVITY.
Galena (sulphide of lead)	2.5 to 2.75	7.5 to 7.6
Sulphate of lead	2.3 to 2.7	6.25 to 6.29
Carbonate (white)	3. to 3.5	6.45 to 6.48
Phosphate (green or brown)	3.5 to 4.10	6.58 to 7.04
Chromate (bright and red)	2.5 to 3.	6. to 6.04
Molybdate	2.7 to 3.	6. to 6.8
Oxide of Tin	6. to 7.	6.5 to 7.
Tin Pyrites	3. to 4.	4.79 to 5.
COPPER.		
Sulphide of Copper	2.5 to 3.	5.5 to 5.8
Oxide	3.5 to 4.	5.9 to 6.
Carbonate	3.5 to 4.	4. to 4.1
Sulphate	2.2	2.21
Silico Carbonate	2.3	2. to 2.2
ZINC.		
Red Oxide of Zinc	4. to 4.5	5.43 to 5.52
Sulphide	3.5 to 4.	4.02 to 4.07
Carbonate	5.	4.33 to 4.44
Silicate		3.43
ANTIMONY.		
Sulphide of Antimony	2.	4.51 to 4.62
Jamesonite	2.	5.5 to 5.8

The concentration and dressing of ores requires a large amount of water. Dry concentration has not proved successful for the reason that air is too light a medium, while, because of its lightness it *does theoretically* seem better suited than water, being more sensitive to slighter differences of specific gravity, it practically causes insurmountable difficulties; being light, it requires great motion to give the particles of ore to be concentrated, the necessary activity for separation, especially in the operation of jigging, thereby largely increasing the attrition, percentage of dust, and consequent loss of metal. In the heavier medium of water the attrition of the ore is a *minimum*, its particles being kept almost *a float*.

The percentage of value obtained or obtainable in the concentrates depends largely upon the character of the ore, upon the proper construction of the machinery employed and upon its proper manipulation. The closer the valuable metal in the ore is concentrated, the greater the loss resulting from the operation.

Ores, the metallic portion of which is very soft, or the metal of which is finely disseminated through the gangue, are not easily concentrated to a high percentage, since, in the process of crushing, the metals they contain are apt to be reduced to a very fine powder that may remain suspended in water for a great length of time, forming so-called slimes, which do not readily yield their value, and are usually run off as tailings; sometimes they are gathered in reservoirs where the metal they contain is given time to settle, and the clear water alone is permitted to run off or pumped back to serve again in the process of concentration. An efficient way of working slimes is the pan amalgamation process, if the pans are properly constructed, and the ore be suitable for amalgamation.

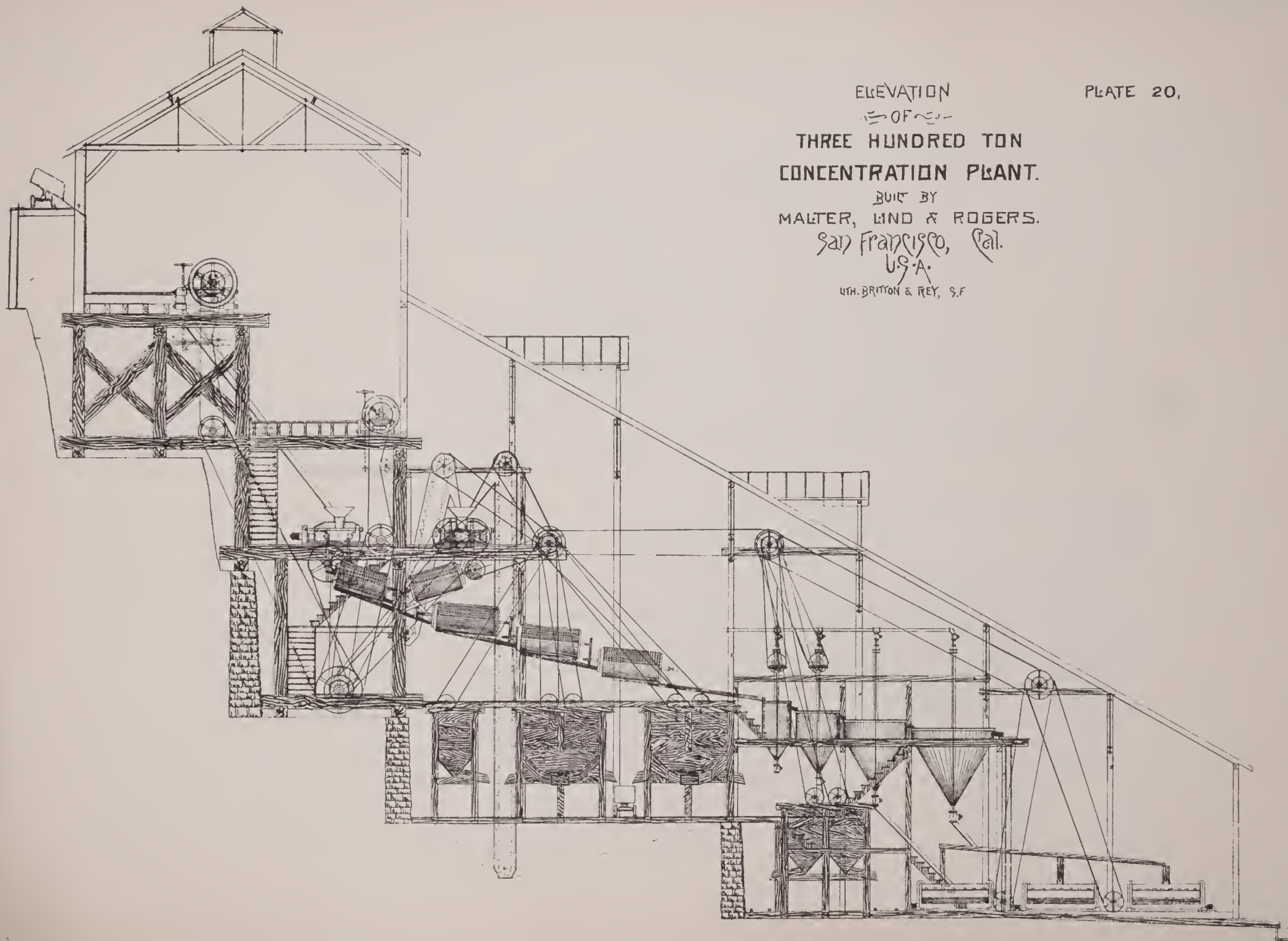
The dressing of ores may be analyzed into the following distinct manipulations:

1. Hand picking.
2. Washing of ores.
3. Coarse and fine crushing in breakers, rolls and stamp batteries.
4. Sizing of crushed ore according to both diameter and shape.
5. Jigging.
6. Working of fine ores upon inclined planes.
7. Working of slimes.

HAND PICKING.

The separation of the solid pieces of metal from the ore containing both metal and gangue, may, to some extent, be effected by hand picking before the ore is crushed. Such separation when possible, is desirable, as it saves unnecessary crushing, and lowers the consequent loss by sliming and concentrating.

The ore may be hand picked two or three times, first as it comes from the mine, and second, as it comes from the coarse breaker, and third, as it comes from the washing machine.



ELEVATION

OF

PLATE 20,

THREE HUNDRED TON
CONCENTRATION PLANT.

BUILT BY
MALTER, LIND & ROGERS.

SAN FRANCISCO, CAL.
U.S.A.

LTH. BRITTON & REY, S.F.

CONCENTRATION WORKS
OF
THREE HUNDRED TONS DAILY CAPACITY.

PLATE 20

Gives a side elevation of Three Hundred-Ton Concentration Plant, which we are now constructing for La Trinidad Mining Company at Trinidad, Sonora, Mexico. The operations in this Mill are, in a great measure, similar to the Silver Queen. The concentrates are roasted and smelted in separate works, provided for that purpose.

TRANSMISSION OF POWER BY BELT.

Each inch of width of a good leather belt, traveling with a speed of 1000 feet per minute, will transmit one horse power. Royers' pulled rawhide belting is capable of transmitting 35 per cent more power than first-class oak-tanned leather belting, and 45 per cent more power than good rubber belting. In wet places rubber belts will wear best, in dry places the pulled rawhide will outlast all others.

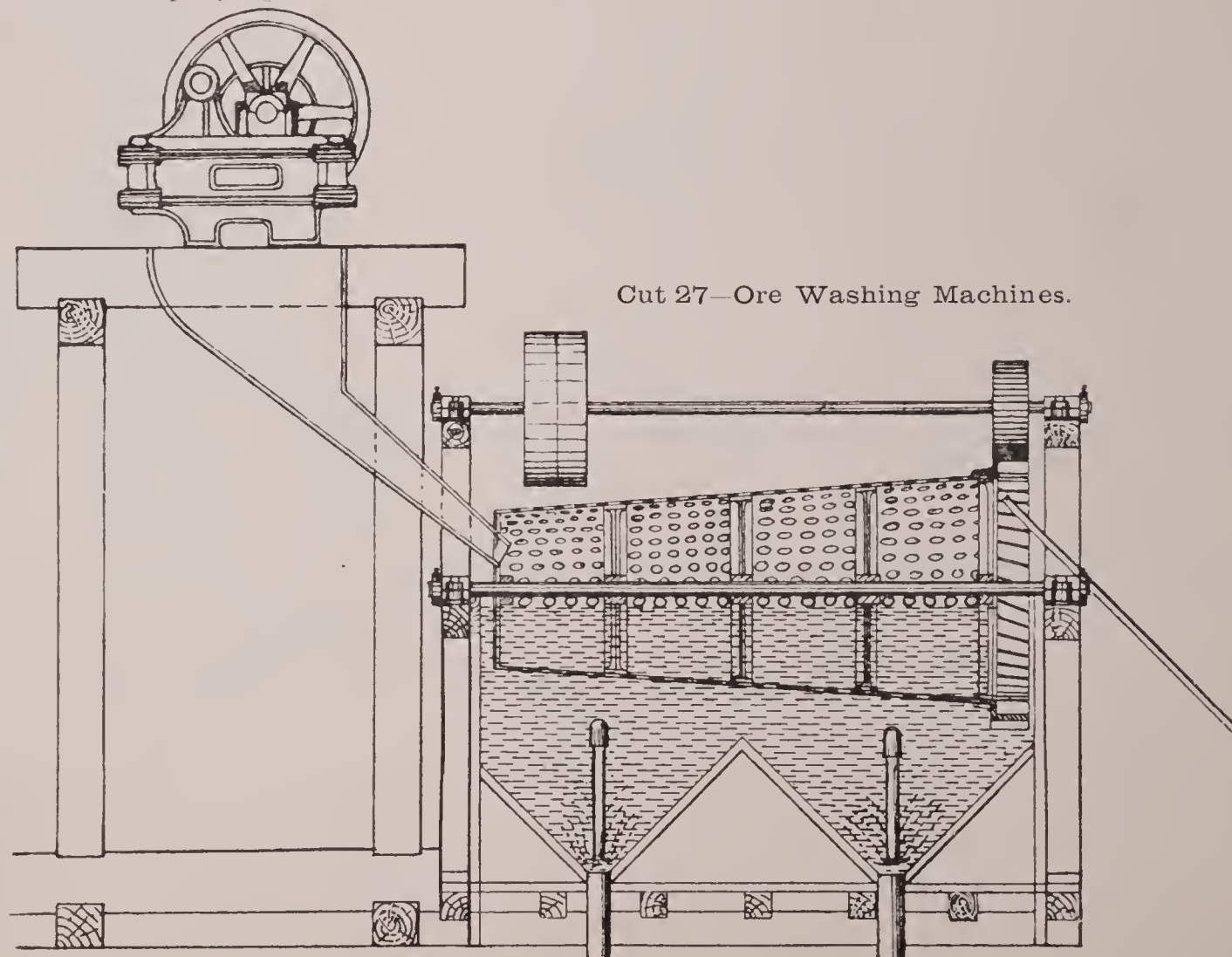
WASHING OF ORES.

The washing of ores is effected either in sluices, or upon revolving tables, or in revolving drums.

Our patented construction of an ore washing-machine of the latter description, is illustrated in the accompanying engraving. It serves two purposes, first, to clean the ore so that the solid pieces of metal may be easily distinguished by the pickers from the impure ore, and second, to separate the various sizes of ore so as to avoid unnecessary crushing and consequent sliming of the ore. We make these machines with single or double cone. The double cone machines separates the ore into more sizes than those with single cones.

The machine illustrated consists of a single revolving cone of perforated plate, which is set upon a tank, and is partly submerged in water. The ore is introduced into the smaller end of the cone as it comes from a coarse breaker. The finer portion passes through the perforations of the cone into the funnel sizer of the tank below, which separates the waste slimes from the ore to be passed to the jigs and tables. The coarse ore which does not pass through the holes of the screen, but passes to the larger end of the cone and is then thrown out by

means of elevator caps, upon an inclined plane, where it may again be hand picked before being passed to the finer crusher or rolls.



Cut 27—Ore Washing Machines.

CRUSHING OF ORE FOR CONCENTRATION.

In crushing ores for concentration, great care must be taken not to reduce any considerable portion of it to a degree of fineness greater than required for separation of the components of the ore, and for concentration. All unnecessary crushing or handling, causing attrition, makes slimes and results in loss.

All machines designed for the crushing of ore to be concentrated, must be so constructed as to avoid all unnecessary grinding of the ore.

Machines which crush the ore by pressure are preferable to those which crush it by blow or grinding motion.

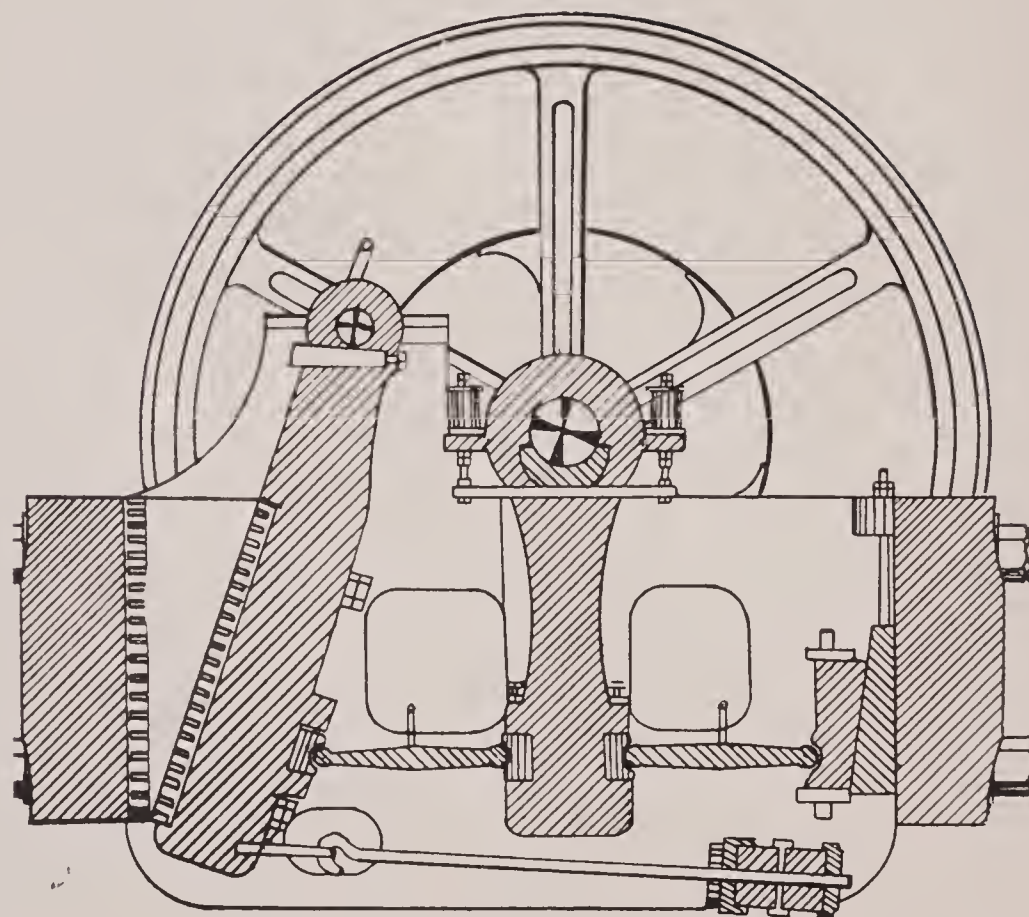
Properly constructed rock breakers make less slime than rigid rolls; rigid rolls make less than cornish spring rolls; and these again make less than stamp batteries.

To avoid sliming, it is necessary to employ rock breakers to crush the ore before passing it to the rolls or stamp battery. First, coarse breakers which reduce the ore to the size of a hen's egg and smaller, and then fine crushers to reduce it to the size of walnuts, and less.

It is also desirable to screen the ore after every operation of crushing, in order to prevent the ore already fine enough, from passing again through a crushing machine and subjecting it to more attrition that causes sliming.

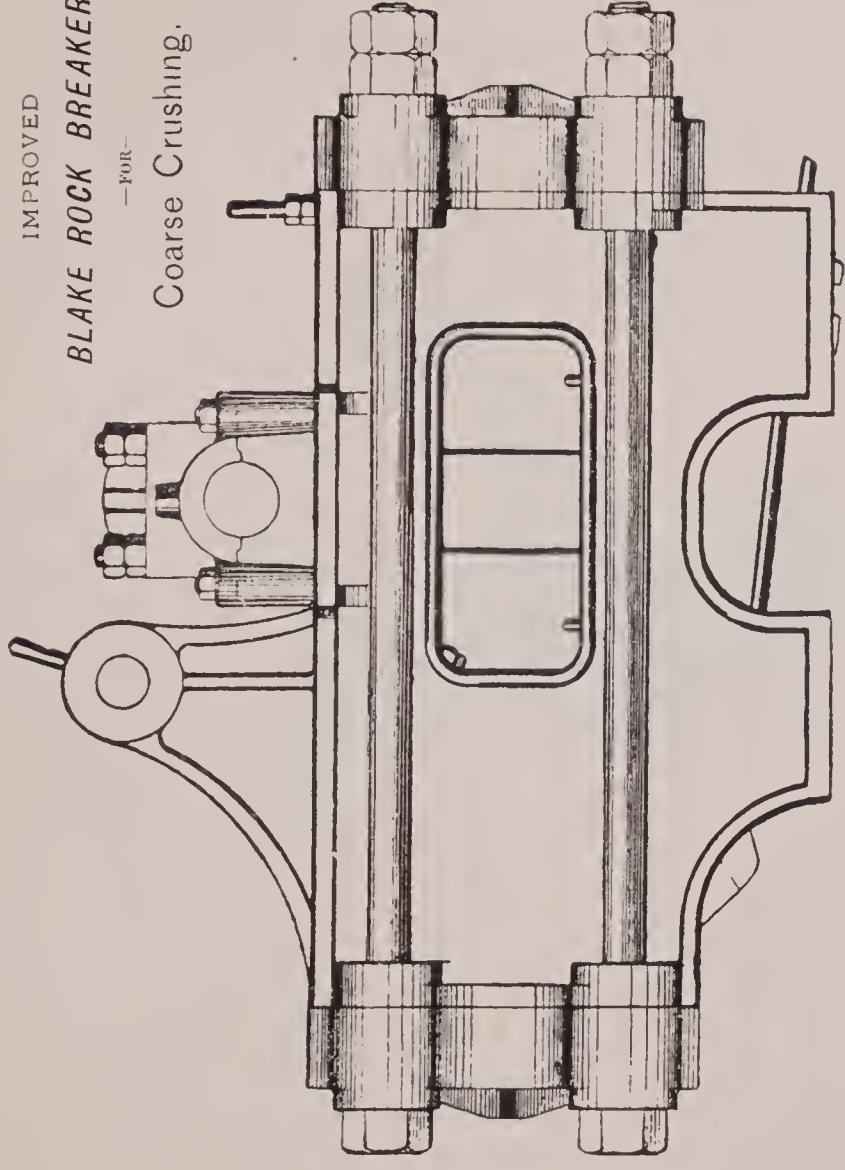
COARSE BREAKERS.

As coarse breakers, we employ the Blake Rock Crusher of improved pattern, as shown on this page and the next.

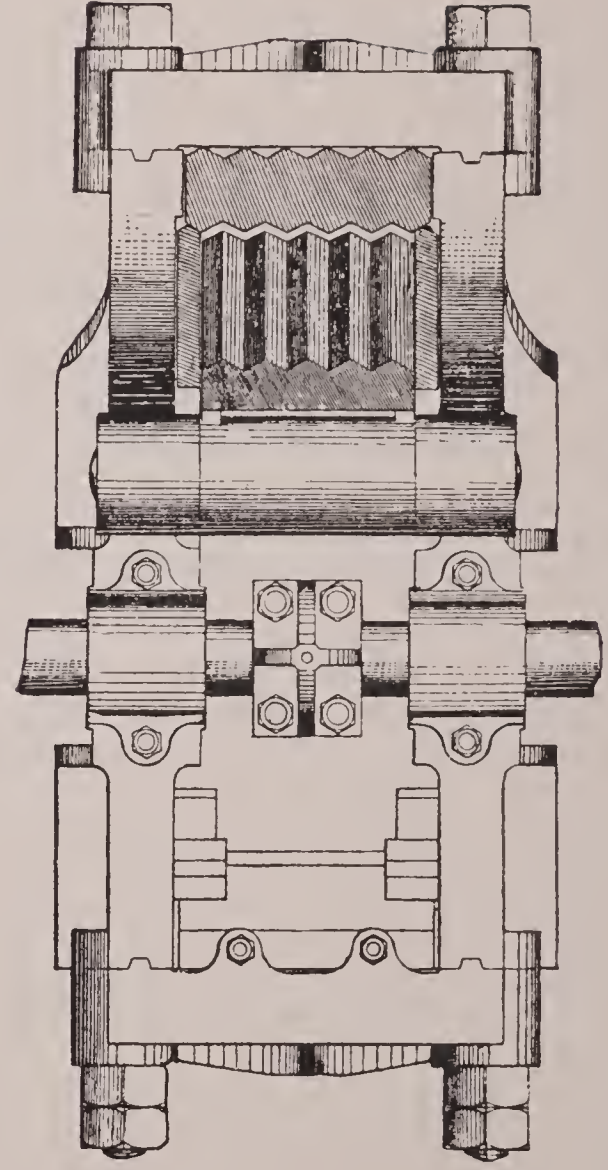


Cut 28—Improved Blake Crusher.

IMPROVED
BLAKE ROCK BREAKERS
 —FOR—
 Coarse Crushing.



Cut 29.



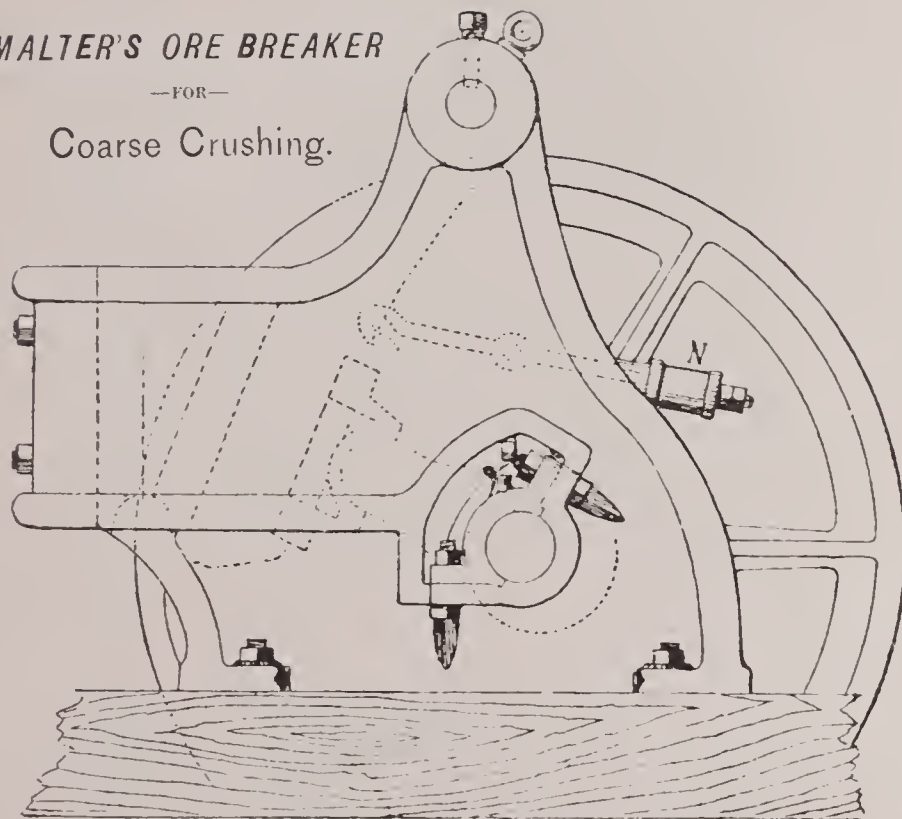
Cut 30.

These crushers are the most commonly used for coarse crushing of ore when large quantities are to be prepared for the stamp battery.

MALTER'S ORE BREAKER

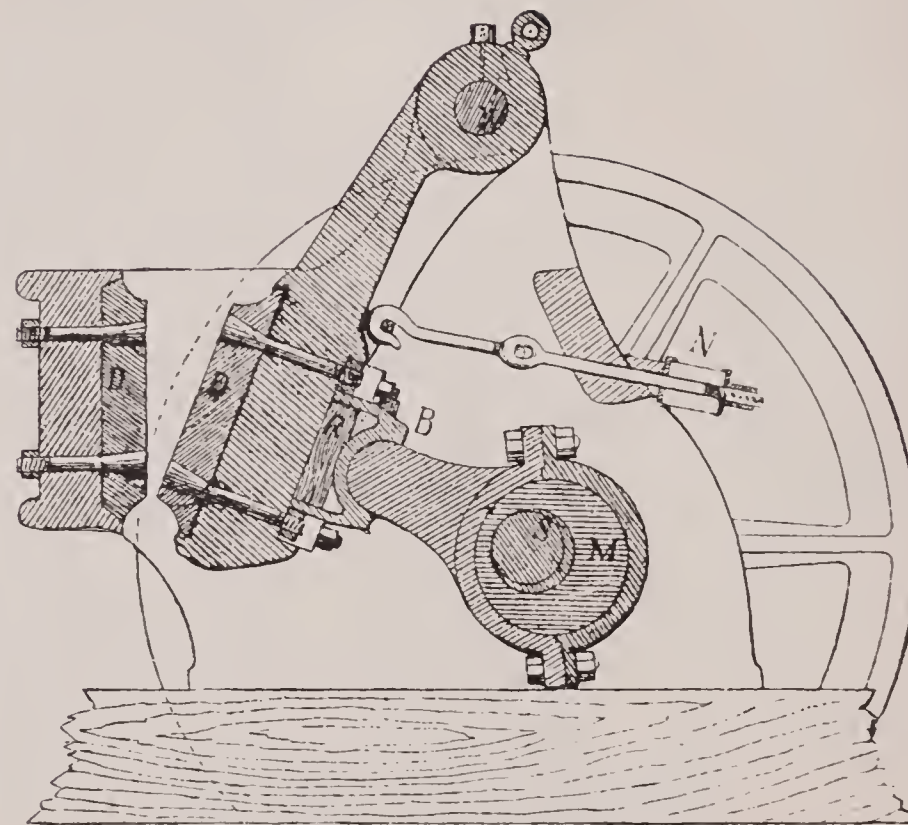
—FOR—

Coarse Crushing.

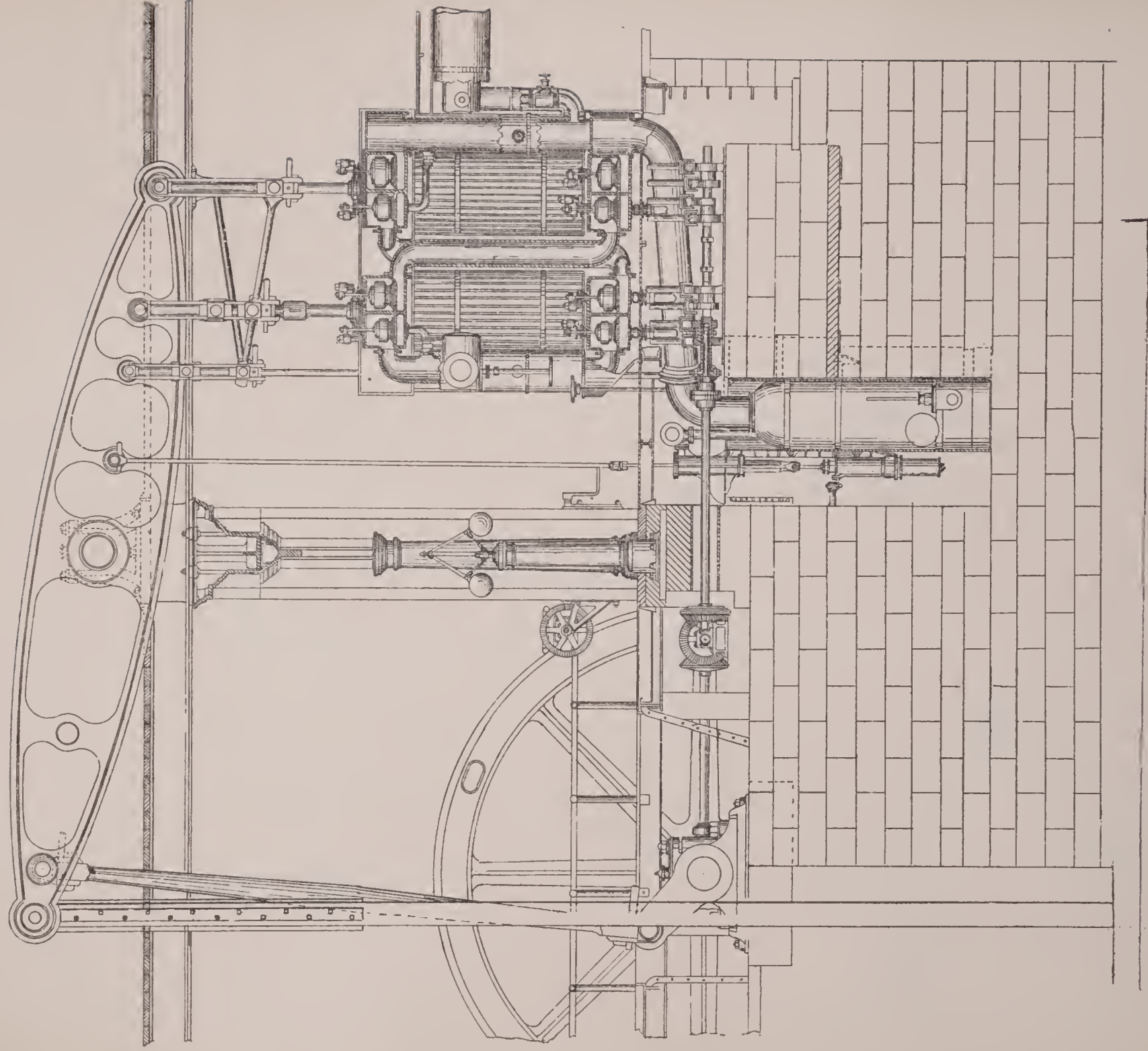


Cut 31—Side Elevation.

This crusher has the advantage of simplicity and adjustability, or stroke, which makes it suitable for ores of varying characteristics.



Cut 32—Sectional Elevation.



COMPOUND PUMPING ENGINES,

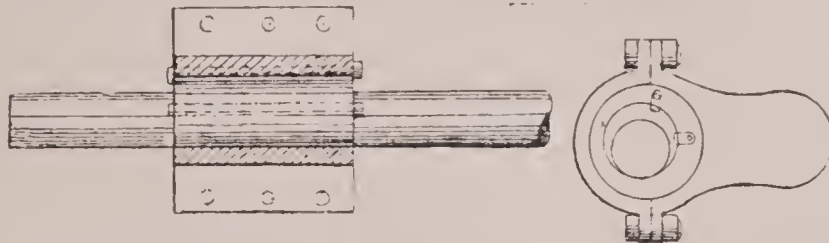
DESIGNED BY

MALTER, LIND & ROGERS.

SAN FRANCISCO, CALIF. U.S.A.

The crushing power is more directly applied than in any other breaker, thereby the number of wearing parts are greatly decreased. A breaking cup B with a rubber block R is interjoined between the toggle and the jaw of the breaker to prevent any serious breakage of the machine, which sometimes occurs when pieces of steel sledges or gads get between the jaws of the breaker.

Cut 33 shows the shaft of the breaker with the toggle and eccentric. All the wearing surfaces are large so as to reduce the wear to a minimum.



Cut 33- Toggle with Eccentrics, to Adjust the Discharge.

FINE BREAKERS.

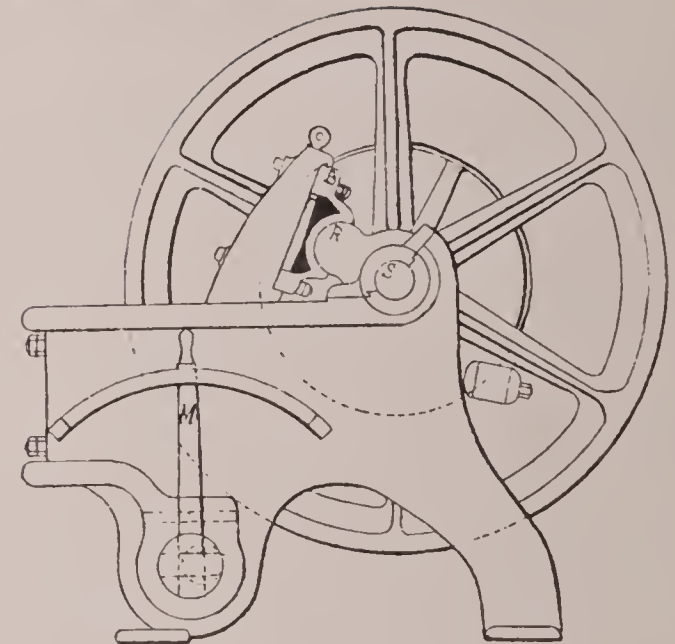
As fine breakers, we employ the Champion Ore Crusher, which is shown in the accompanying plate.

It has two peculiar features:

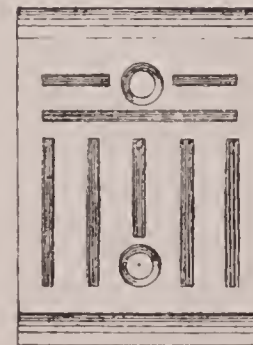
1. Its jaw has its minimum motion below, at the discharge; by this means it becomes possible to crush the ore uniformly finer than in the other breakers.

2. Its discharge opening is easily adjustable by means of an eccentric, which is operated by the lever M, so that when the jaw plates wear the discharge opening may still be kept of the original and uniform size.

A breaking cup R, is placed between the moving shaft and the movable jaw, to prevent disastrous breakage of the frame, which sometimes occurs. We use patent steel jaws in either of these breakers, or we make the jaws, as shown in cut, of cast or wrought iron or of steel. Tempered steel bars are firmly inserted into it. All the workmanship and material of these crushers is the best of their kind.



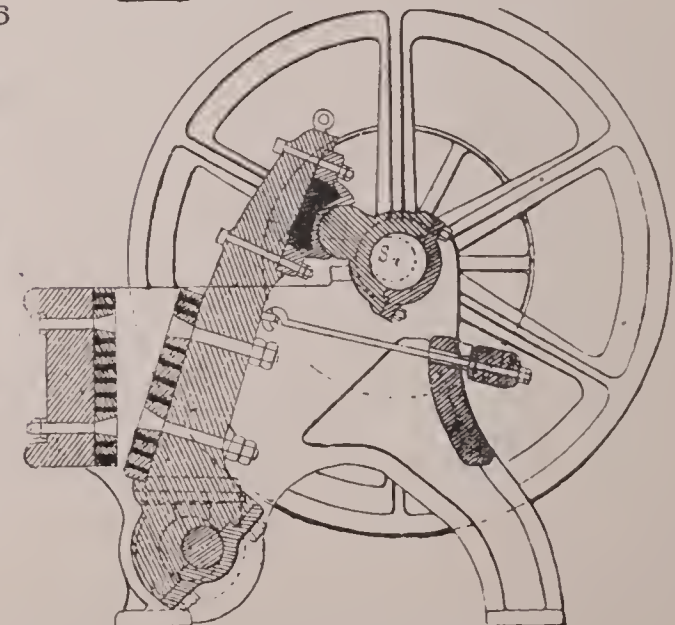
Cuts 34, 35, 36



JAW PLATE

—WITH—

Steel Bars.



Champion Breaker for Fine Crushing of Ore,

ROLLS FOR CRUSHING ORE.

Cut 38 illustrates Malter's patent rolls, for which we claim superiority over other rolls in use, on ground of the following points:

1. They are more substantial.
2. The gears being placed directly over the pinion, do not require long teeth or constant adjustment, as do all other geared rolls, to accomodate the motion of the movable roll, or the wear of the shell.
3. The shells of the rolls are easily removed without disturbing the gears.
4. Both shells may be turned off at once in case of wear.
5. The rolls are so guided by means of a wrought-iron frame that they cannot twist as they are thrown apart, thus all danger of breakage of gears is avoided.
6. If used as rigid rolls for fine crushing, the distance between the rolls, and thereby the size of the grains required, is easily adjusted by means of the breaking cup.
7. The same set of rolls may be used as rigid or movable rolls, by making but the slight change of exchanging the breaking cup for springs.

We make the shell of the best material; we bore them out so as to fit true on a tapering conc. The roll shafts we make of best hammered iron or steel.

Coarse crushing or so-called roughing rolls should be used with a movable roll held in place by a suitable spring, and they should be driven by gears.

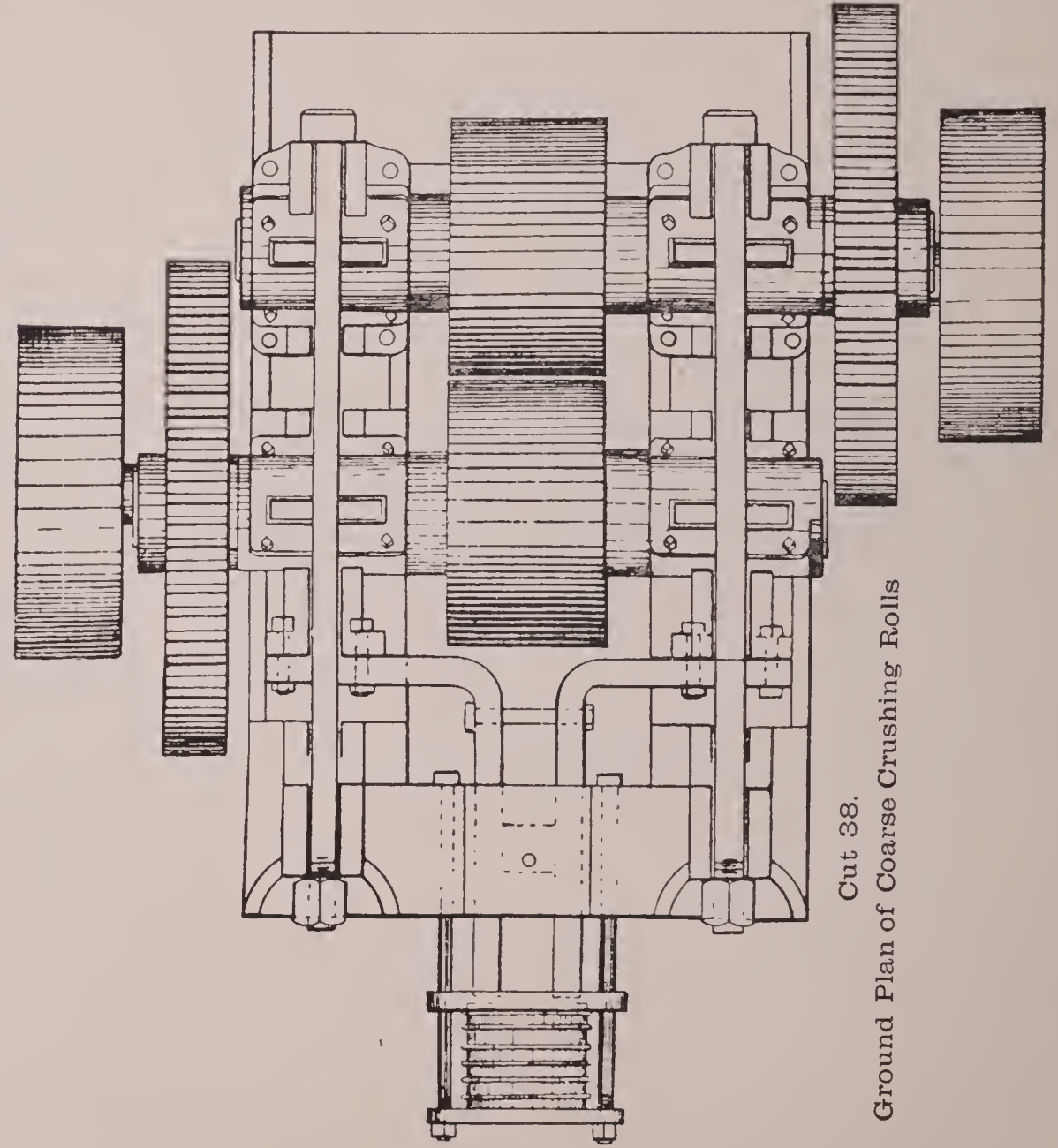
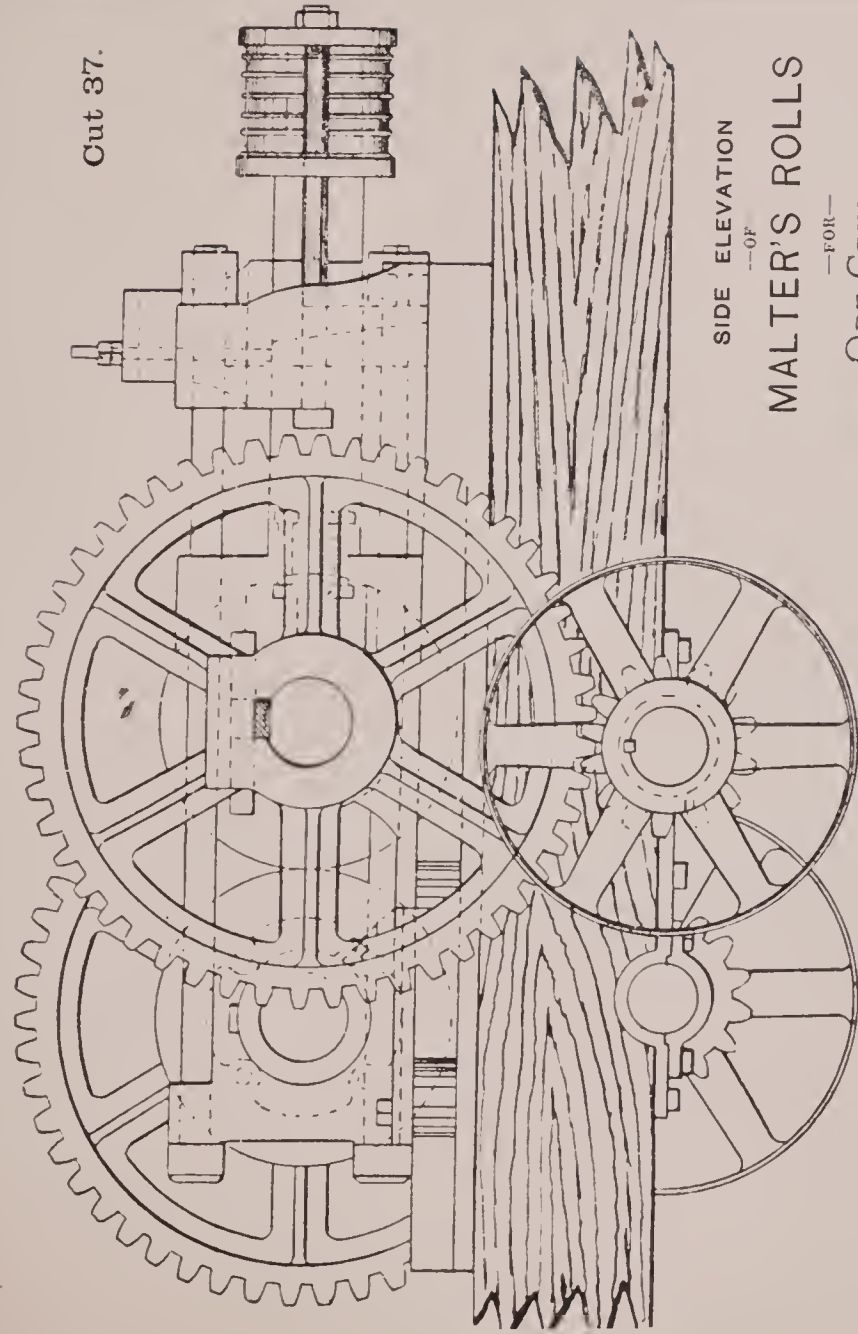
Fine crushing or finishing rolls should be used as rigid rolls to prevent making slimes, and are better driven by a large belt-wheel direct, without the use of gears.

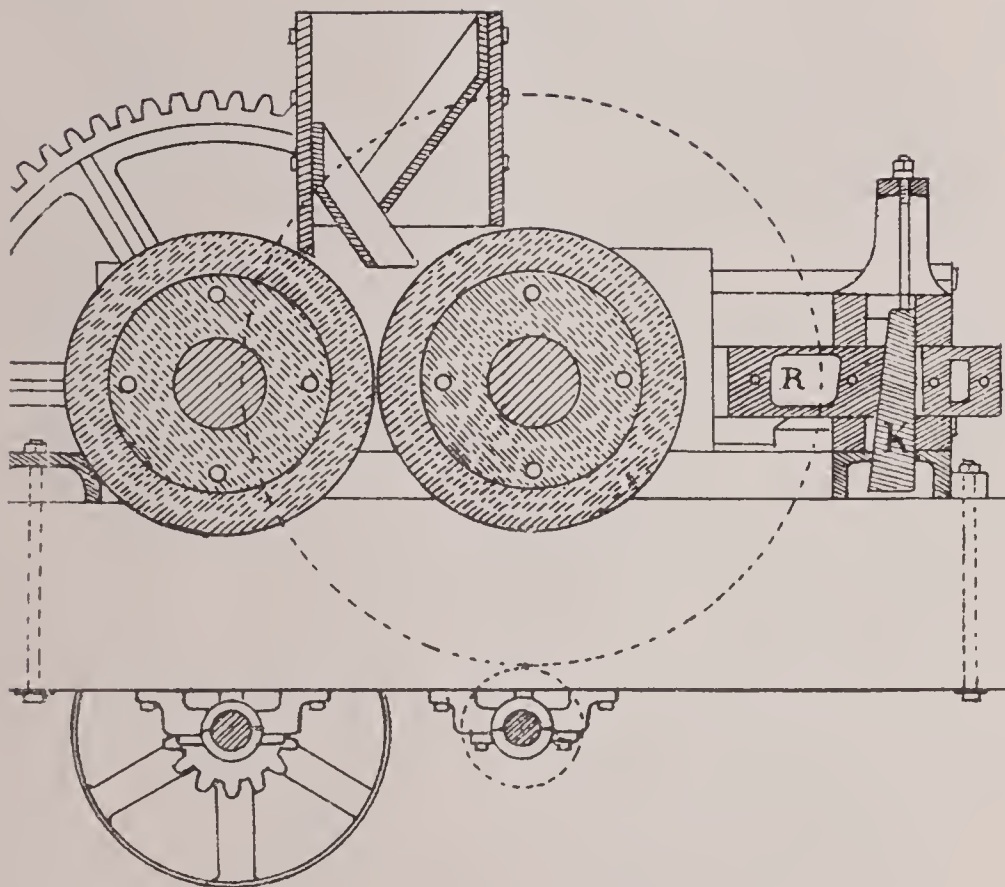
When the metal of the ore to be concentrated is finely disseminated through the ore, it is often advantageous to crush the ore, or at least the "seconds" from jigs, in a stamp battery. To avoid sliming as much as possible in such cases, a water-box should be attached to the outside of mortar in such a manner as to submerge the screen entirely in water, and thereby prevent the clogging of the screen, which increases the percentage of slimes materially. An arrangement of this description is illustrated on page 7.

Another effective method to prevent sliming, is that of crushing over the edge of a board into water-boxes outside the mortar, which, in such cases, serves as sizer, and does the duty of a pointed box or spitz-rasten.

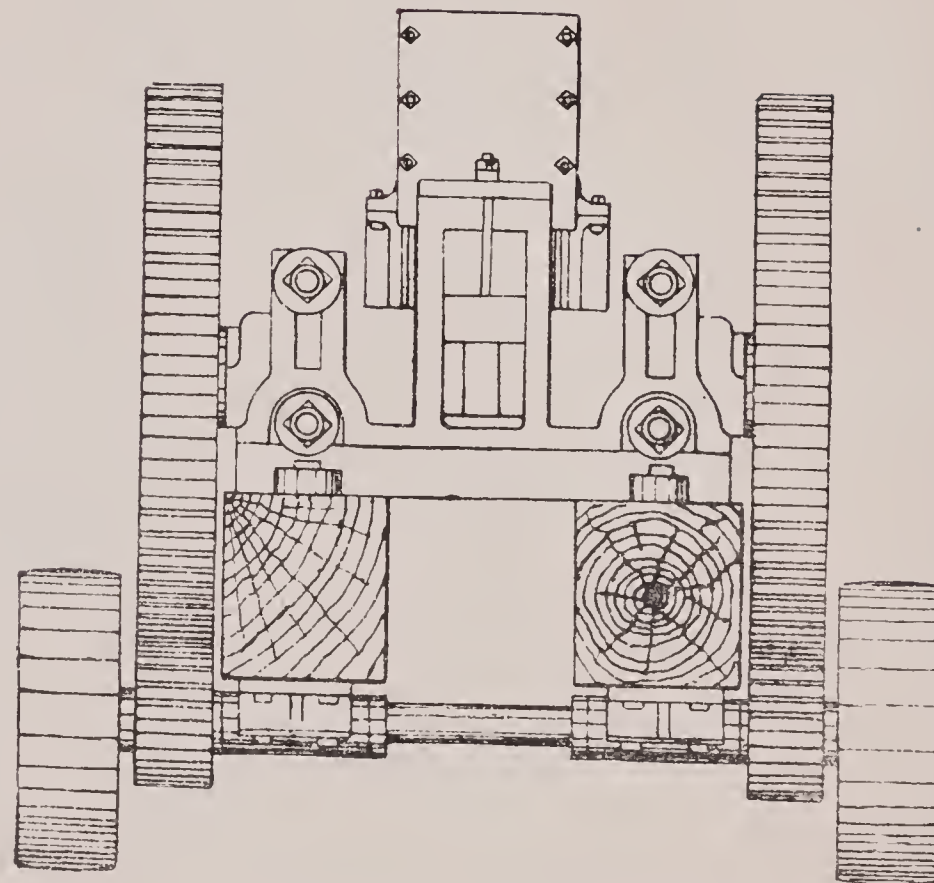
The more water run through the moisture while crushing the sooner will the fine ore be discharged and the less slimes will result.

On the following pages we show cuts of our patented constructions of coarse and fine crushing rolls, such as we build for use in concentration plants.

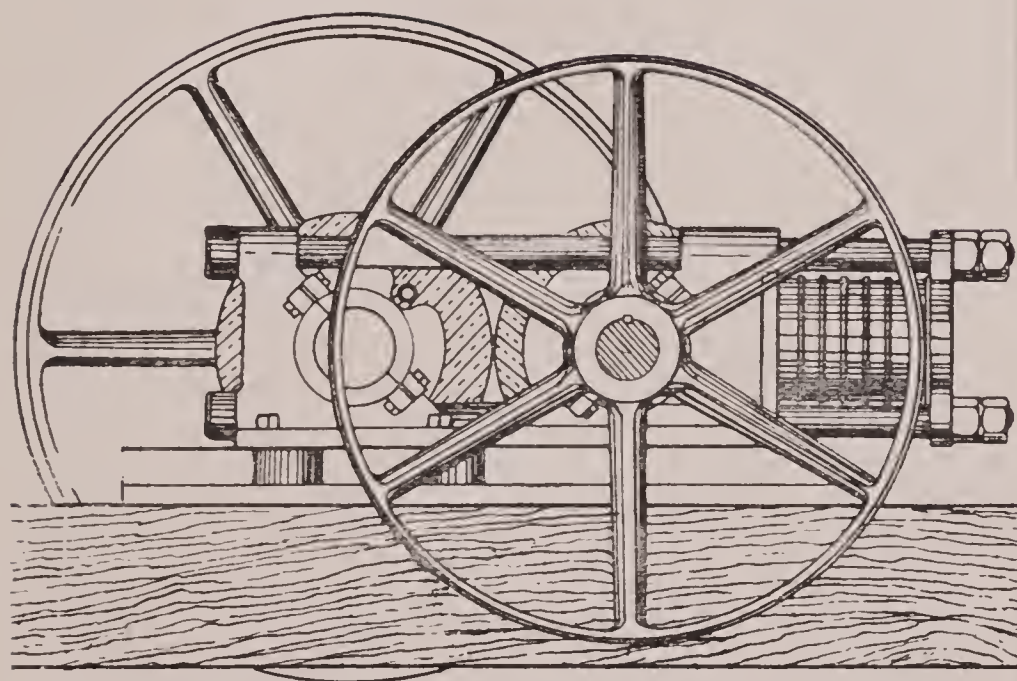




Cut 39--Sectional View of Malter's Rigid Rolls for Fine Crushing.



Cut 40--End View of Geared Rolls.



Cut 41—Malter's Spring Rolls for Fine Crushing of Ore.

In wet concentration plants the stuff produced by crushing in rock-breakers and coarse-rolls is separated by revolving receiving drums, through the screens of which the finer material passes by chutes, directly to the sizing screens, while that which is too coarse to pass is returned by elevators to fine crushing rolls. Cuts 39 and 40 show Malter's rigid rolls for re-crushing of ore, and cut 41 illustrates spring rolls for fine crushing.

The sizing screens separate again the sands and slimes from the coarse material, and carry them to the spitzkasten or hydraulic separators, which in turn feed the percussion tables or concentrators. The coarse material from the sizing screens is distributed to the jigs. The size of this stuff ranges from an eighth to a thirty-second of an inch in diameter, and sometimes in lead and copper works larger, and in silver mills smaller. The jigs are provided with flat steel bars to receive wire-screens having meshes corresponding to the size of the material to be treated, also to the sizing screens feeding the jig.

The jigs constructed by us, are continuous working, that is, they are fed continuously by the sizing screens, and are also self-discharging. The separation of the metal and gangue in the jigs is effected by water actuated by plungers or pistons, worked from horizontal shafts by eccentrics and rods forcing the water up through the screens, lifting the ore particles deposited upon them.

By this means, the material is lifted and dropped, varying in speed or number of strokes from eighty to one hundred and fifty, according to the fineness of material treated, the heavier metals reaching the screens first, while the lighter gangue remains on top, and is gradually worked along from one screen to another, until it is finally discharged from the waste gate, located at the opposite end of the jig frame from which it enters, while the metal and valuable stuff partly passes through the screen or is discharged from gates in front into the receiving boxes underneath, and from them carried away in cars for further treatment—roasting, smelting, leaching, etc., as each case may require.

The material coming to the jigs, in which metal and gangue are yet mixed in the grains, and which therefore cannot be separated by jigging, but requires to be re-crushed, pass through side gates to rolls provided for that purpose.

All the operations can be regulated so that practically nothing but pure waste is discharged, and only the valuable metals saved, providing always, that the jigs are properly managed and the screens are selected to suit the ores to be treated.

We also construct jigs for treating fine stuff which is commonly worked with the slimes on tables. The successful operation of the jigs depends very largely upon the ability of the operator to adjust them to the work.

SIZING SCREENS.

The sizing screens we generally build cylindrical in shape, with convenient devices for securing and removing the screens when necessary; they are driven either directly by belts from counter shafts, or by bevel and spur gearing when worked in sets from one driver. The carrying shafts are preferably made of tubing with solid journals and double adjustable bearings.

Each screen is provided with sheetiron receiving aprons, which supply the succeeding screen; spouts are also arranged to deliver the proper material to the jigs. These screens are made of sheetiron punched with numerous holes to correspond to the jigs which they serve.

In the work of concentration the very fine sands and slimes are conducted by spouts from the sizing screens to the hydraulic separators which feed the slime jigs and tables (see page 24).

These separators are arranged in sets of three or more, depending upon the characters of ore treated. If much slime is to be handled then more and larger separators must be used. These separators or pointed boxes operate upon the principle that the finer the sands the greater the water surface and the slower the motion needed to settle it, therefore, in operating, the coarsest sands are collected in the smallest separators, the current being so rapid that only the heaviest particles sink while the rest overflows into the next larger tank, where the same quantity of water flowing in, spreads over more surface, and the next size is settled, and so on to the end of the system, when the last overflow carries away the slime waste and surplus water. In some locations where the necessary water is scarce the last overflow, when settled and clean, is pumped back to be used again, though this not desirable if it can be avoided.

The sands collected in the separators are fed continuously to the slime jigs and tables where both are used, and the entire plant is thus continuously working and as nearly as possible automatic in all its departments, from the delivery of the ore in the ore-house, to the concentration of the slimes, each set of machines depending for its supply upon the next above.

In distributing the slimes and sands upon the percussion tables or other concentrators, it is necessary to have the stuff sufficiently diluted so that it can be spread evenly over the tables near the top of the incline, in a thin sheet, so that the work of the table can better act upon the particles; clean water is also introduced upon the table, which tends to wash away the mineral sands and the gangue, but the metallic portions being heavier, resist the action of this water more than the gangue, a partial separation is thus effected, which is more fully accomplished by the quick jarring motion which the table receives by means of cams acting against springs, and operated by pulleys and belts from counter-shafts, or by other contrivances, giving the whole table a side-wise or end motion, which is partly arrested by striking against percussion blocks.

The tendency of the material upon tables is to form lines of descent more or less curved; the lighter portions generally nearly straight, and the heavier metallic portions in curved lines; three lines are formed—one of pure metal, one of pure waste or gangue, and one of mixed metal and waste, if rich enough, is worked over again on the same table, or upon tables located beneath, to receive the material from the tables above, or if the middling stuff is not valuable enough to be worked separately, it is either mixed with the pure metal, or allowed to follow the waste.

The character of the surface of the table and the incline given to it have much to do with the work done; the greater the incline the less clear water is used, and the reverse. The construction and adjustment of these tables is an important feature in the successful working of slimes. With properly constructed table the loss in working sands or slimes is very trifling, a high percentage of the value of the slimes can be saved, varying with the character of the ore.

Belt concentrators, such as the Frue or Triumph Machines, are also used for concentrators of slimes.

The relative value of these different styles of concentrators depends upon the class of work to be done; for gold sulphurets, the endless belt machines, like the Frue and Triumph, are mostly used at present; this arises from the fact, that the percussion table proper, has never been practically introduced for this purpose.

In works designed for concentrating silver ores which easily slime the percussion table is by far the most efficient machine; and since the concentration of sliming silver ores is far more difficult than the concentration of iron pyrites from gold-bearing quartz ores, it would seem reasonable that a percussion table properly constructed for the purpose would also be more effective for saving gold sulphurets.

PAN AMALGAMATION.

The process of extracting gold and silver from their ores by pan amalgamation is a California invention.

Since it came into use the amalgamating pan has undergone very many material changes. The main features of its improvements consists in bringing the ore to be amalgamated more effectually in contact with the mercury, thereby increasing the efficiency of the apparatus and shortening and cheapening the process.

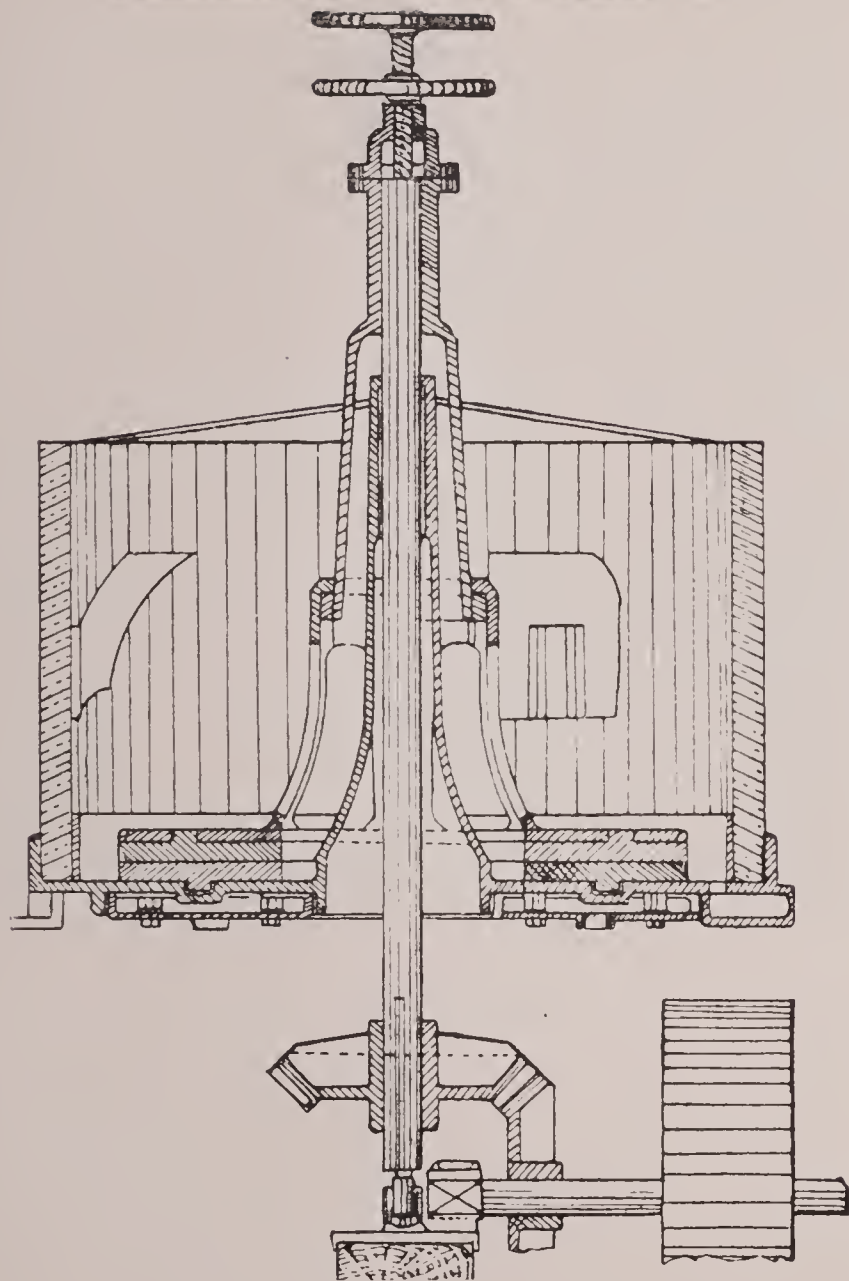
COMBINATION PAN.

Cut 42 shows the combination pan which is still extensively used in silver mills. It is generally 5 feet in diameter and 3 feet in depth; its sides are made of wood when the ore to be worked in them has previously been subjected to a chlordizing roasting, otherwise they are more usually made of cast iron, occasionally, also, of wrought iron.

Underneath the pan bottom there is a steam chamber, into which the exhaust steam from the engine is usually introduced for the purpose of heating the ore pulp and mercury.

The inside of the pan bottom is covered by dies made either in sections or in a solid ring. The pan muller with its shoes entirely covers the dies. The space between the dies and their outer and inner periphery are usually filled with wood or cement so as to preserve a smooth surface over the entire bottom of the pan.

The center of the pan bottom rises in the form of a high cone, the upper part of which serves to hold the upright shaft or pan spindle, that transmits the power and revolving motion by means of a driver to the pan muller, revolving it in a horizontal plane above the pan bottom or dies.



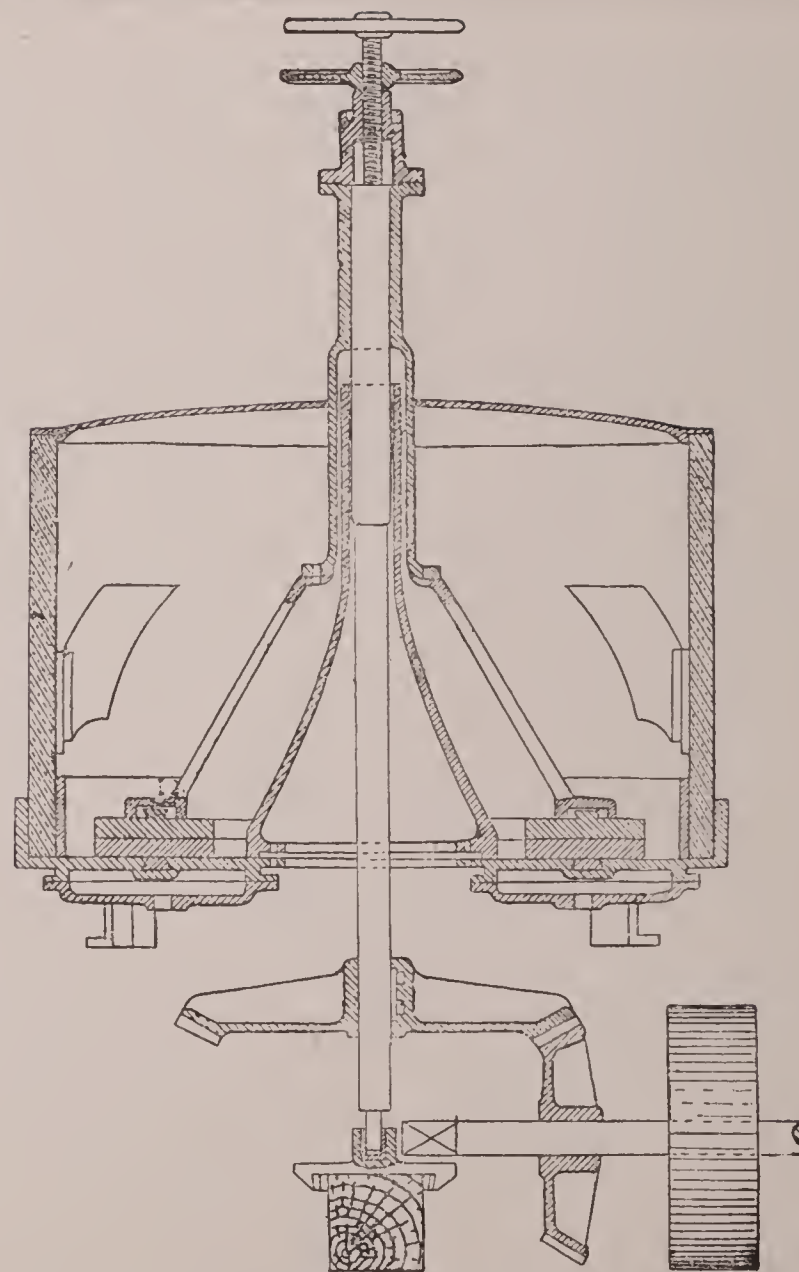
Cut 42—Improved Combination Pan.

The distance between the shoes and dies may be adjusted by means of screws and hand wheels bearing at the upper end of the spindle.

The pan may be used either for the purpose of grinding or amalgamating.

When the pan is used for the purpose of grinding the ore pulp, the screw is raised and the muller with its shoes is thereby lowered so that its weight rests upon the dies. When the pan is used as an amalgamator then the muller and shoes are raised from $\frac{1}{2}$ to 1 inch above the dies.

In this construction of the pan, the muller plate covers the entire surface of the dies and the arms of the muller are attached to the inner periphery of the muller plate. When in motion the arms and muller plate virtually forms a partition between the bottom of the pan upon which the heavy mercury used in the amalgamating of ore gathers and the upper portion of the pan which holds the lighter ore pulp. To bring about a thorough mixture of the two, the muller is made to revolve very rapidly—65 or 70 revolutions per minute—thereby the mercury beneath the pan shoes is divided or shattered in small globules, which are forced upward into the ore pulp and float in it if the pulp be sufficiently stiff.

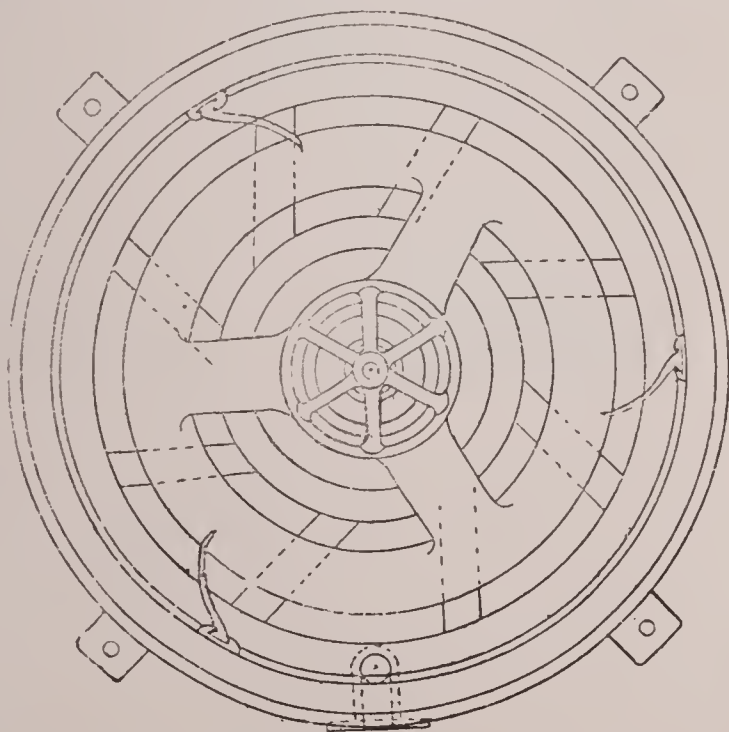


Cut 43—Standard Pan.

STANDARD PAN.

Cut 43 and 44 shows an amalgamating pan of a later construction, first introduced by us in the mills about Tombstone. It differs from the former in having a narrower muller, the shoes projecting from 5 to 6 inches beyond either edge of the muller.

The object of narrowing the muller is to bring the ore to be amalgamated more effectually into contact with the mercury, which being heavy, generally gathers at the bottom of the pans. As the muller revolves the beveled edges of the shoes attached to it force the pulp through the spaces between them in a downward direction into the mercury, which is thereby made to take off the revolving motion of muller and pulp, and is more readily mixed with latter than in the former construction of pan, hence the motion of the muller need not be rapid nor the ore pulp so thick to effect the same result.



Cut 44—Ground Plan of Standard Pan.

SETTLER.

The engraving on page 67 represents a sectional view and ground plan of a settler as commonly used in silver mills, for the separation of the amalgam and mercury from the ore pulp as it comes from the pans.

It is an open vessel, the bottom being of cast iron, sides of wrought iron or wood, from 8 to 9 feet in diameter, sides from 3 to 4 feet high. An upright shaft, which receives its motive power through the gear wheels, transmits a rotary motion to a muller-plate or arms carrying wooden or iron shoes.

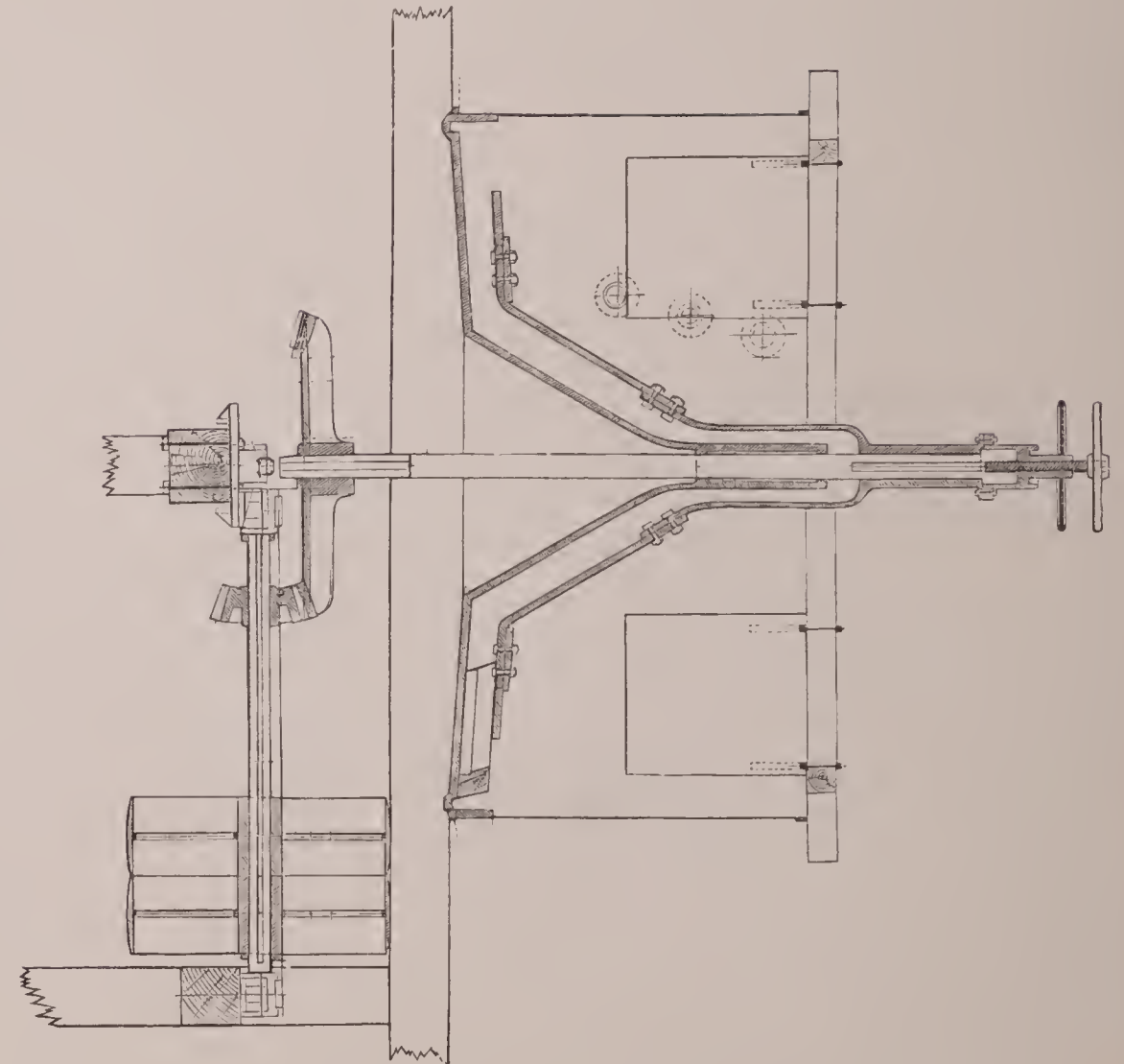
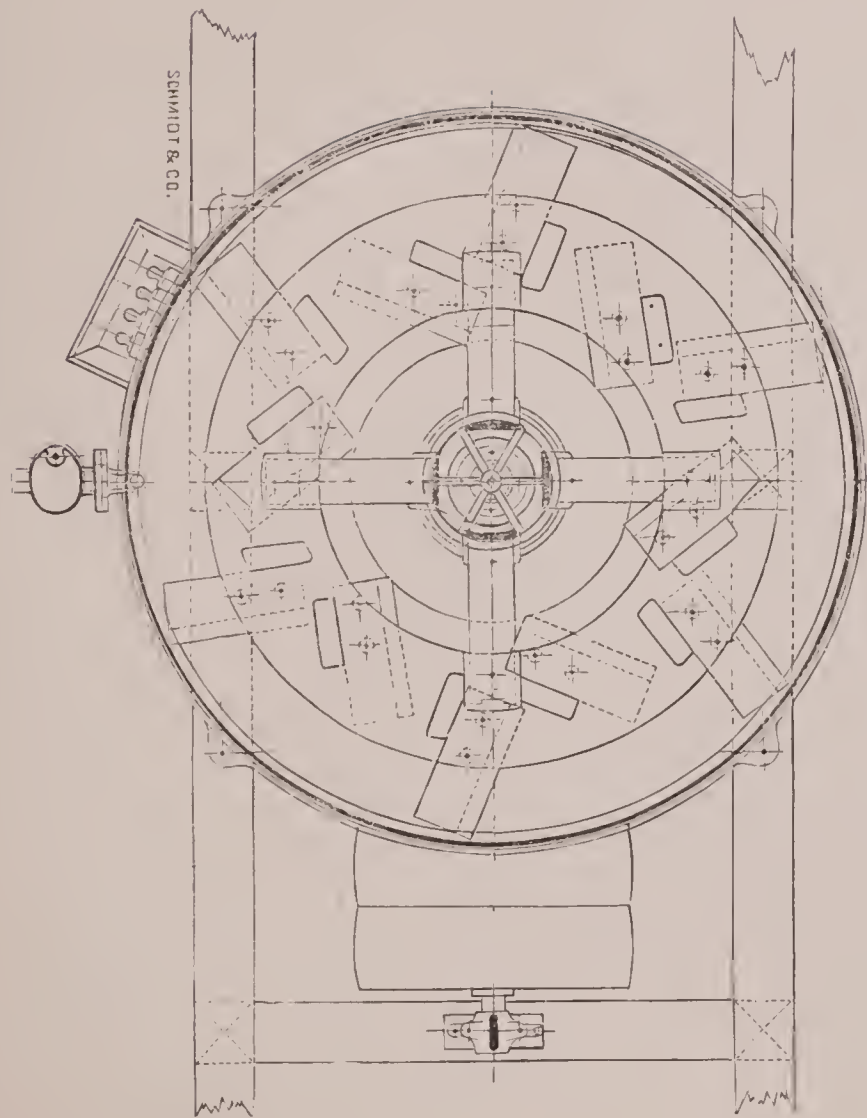
The ore pulp coming from the pans is greatly diluted in the settler to facilitate the separation of the heavier portion, which contains the amalgam and mercury and which sinks to the bottom from the lighter sands, which pass out through holes in the sides of settler into the waste sluices or the funnel separators.

The mercury and amalgam gather in a bowl attached to the outside of settler near its bottom.

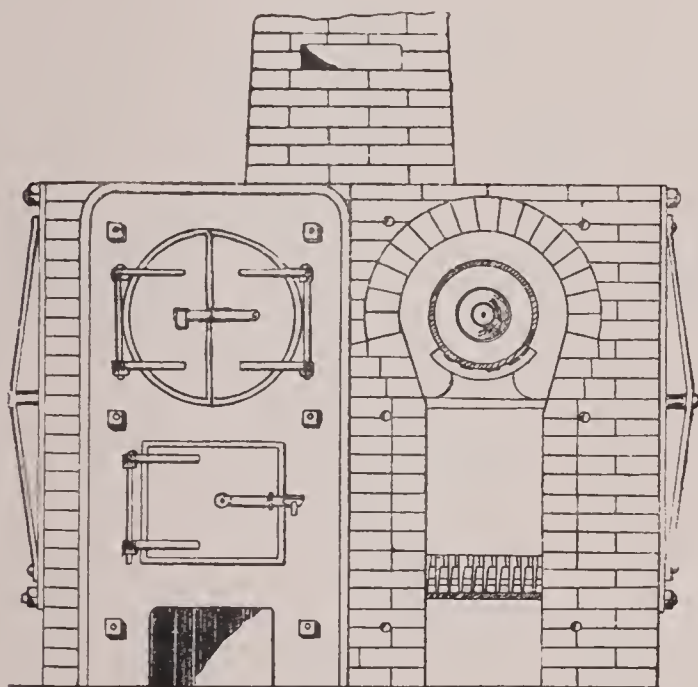
Dashboards are commonly suspended in the pulp as shown in the sectional view of settler, for the purpose of deflecting the circulating sands toward the bottom of settler and thereby facilitate the separation.

The settler is a continuous working machine, although the pulp from the pans is not always continuously charged into it.

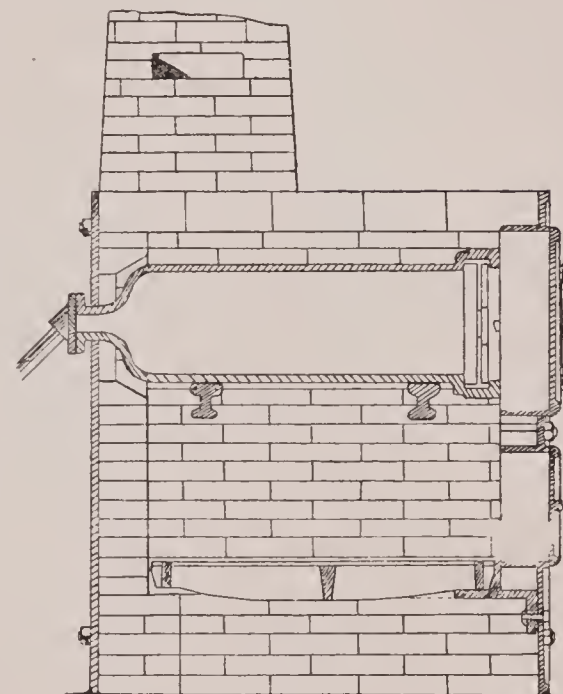
One settler generally serves two pans; only in exceptional cases is it necessary to employ a settler for each pan. In some cases one settler may be sufficient to separate the ore pulp coming from three or more pans, as in the continuous charge mill and others. In gold mills with our continuous-pan amalgamation process the settler may be entirely dispensed with, the continuous-working separators taking its place.



Cut 43



Cut 44.



Cut 45.

Retorts for Silver Amalgam.

AMALGAMATION OF GOLD IN THE STAMP MORTAR AND IN THE PAN.

The gold contained in the quartz as found in our mines is usually separated from its matrix by amalgamation in the stamp battery and upon copper plates coated with mercury, which are placed in the bottom of the sluices that carry away the tailings.

Very pure and coarse gold can be readily amalgamated in this manner, although the percentage of loss in this primitive process of mortar and plate amalgamation is always great, far greater than the majority of millmen are inclined to admit. But when the gold is not pure and coarse, for instance is rusty, covered with oxides of iron or copper from decomposed pyrites, or is very finely divided through the quartz, or is in alloy with some silver, as is very frequently the case, then the battery amalgamation is not usually found to give satisfactory results. Mines containing such ores are very frequently condemned as worthless when the customary treatment of the ore by mortar amalgamation fails to yield a profitable result. More effective methods of amalgamation are but little known and but rarely resorted to. Thus, for instance, the mines at Bodie, Cal., were, shortly after their discovery, abandoned for the reason that the ordinary amalgamation process in the mortar, or pan, failed to extract the gold, which is very fine, and in alloy with some silver. It was ten years after their abandonment that a somewhat improved pan-amalgamation process was introduced by us, at the Standard mine, Bodie, which proved successful and turned the deserted camp into one of the most prosperous mining districts of this coast.

Clean and pure metallic gold, if not so fine and slimy as to float on the water, unites very rapidly with even cold mercury upon mere contact with it; but fine, slimy or rusty

gold, or gold in alloy with silver, will not readily amalgamate with mercury, hence more efficient means than the slight, uncertain and inefficient contact with cold mercury in the mortar or upon mercury-coated copper plates must be employed to amalgamate gold that occurs under such conditions.

Mr. Raymond, United States Commissioner of Mining Statistics, has treated the important subject of gold and silver amalgamation in his official reports. He has clearly shown the wastefulness of the crude mortar amalgamation process in all cases; he asserts and proves that as much as 50 to 60 per cent. of the value of gold-bearing quartz are usually lost in stamp-mills which are considered to work successfully.

The great loss of precious metal may be principally attributed to the following causes:

1st—The mercury in the mortar and plate amalgamation cannot be heated, and quicksilver when cold is far less efficient in its power to dissolve precious metals than it is when heated to about the boiling point of water. If hot water were used in the stamp mortar for the purpose of warming the mercury the latter would not adhere to the amalgamation plates.

2d—The mercury which is placed into the mortar stays largely at the bottom and does not come into favorable contact with the ore to effect the amalgamation of the metal.

The amalgamating plates which are placed outside of the mortar, and which are intended to catch the amalgam and float gold that escape from it, do not usually answer their purpose with much efficiency; they do not present the most favorable condition under which amalgamation can take place. The constant current of water flowing over them carries much of the amalgam away with it as also gold, especially when they are new and but thinly coated with

mercury the copper is apt to oxidize and become covered with a greenish coating which quite prevents the adhesion of the floating amalgam to it.

3d—It is impossible to put the mercury in the best condition to unite with the precious metal, first for the reason that confined in the mortar it is not accessible to the inspection of the amalgamator, and secondly, if cyanide of potassium or sodium amalgam or other re-agents that may be needed to preserve the amalgamating power of the mercury be added, their power would be largely lost in the great currents of water that flow through the mortar. If clean gold-bearing quartz is worked, the mercury in the mortar is not apt to get foul speedily; but if impure ores are to be treated in the stamp mortar then the quicksilver may lose its capacity to unite with the metal.

4th—The attrition of the sands consequent to the action of the stamp is apt to "flour" the mercury and amalgam, causing it to be carried away with the water.

Of floured metals, Mr. Raymond says: "Flour or granulated quicksilver and fine particles of gold have, in common with some other polished metals, the property of condensing on their surfaces films of air which practically decrease the specific gravity of the particle and cause it to float in the water or upon its surface, whereby serious loss of precious metal is occasioned."

AMALGAMATION OF GOLD IN PANS.

The ordinary pan-amalgamation process overcomes the first but not the three last of the above-mentioned defects in mortar amalgamation, and hence the ordinary pan process does not usually prove efficient where mortar amalgamation fails. Moreover, the cost of the ordinary pan amalgamation is fully 50 per cent. higher than that of the mortar amalgamation, and the first cost of the plant twice as great.

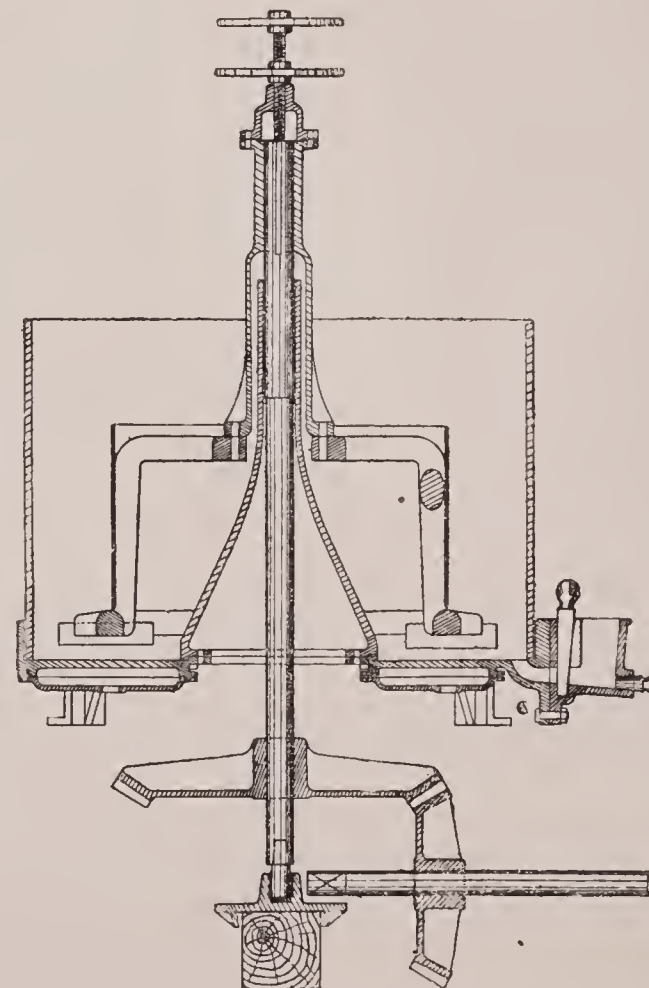
MALTER'S CONTINUOUS-PAN AMALGAMATION PROCESS.

For the working of gold and silver ores which are difficult to amalgamate by the ordinary battery and pan amalgamating process, we have designed and patented an improved method of continuous-pan amalgamation, which successfully overcomes the difficulties stated above.

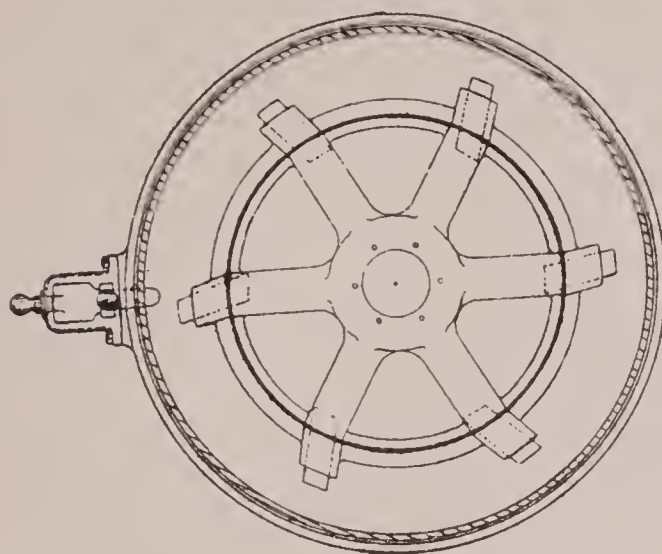
It differs mainly from the ordinary methods of continuous or other pan amalgamation in the construction of the pan and in the substitution of our patent tailing separator for the customary settler and in the method of using the mercury in the pan.

Plates 7 and 13 show plans of such improved gold and silver amalgamating mills.

Cut 49 shows a sectional view



Cut 49—Malter's Patent Amalgamating Pan.



Cut 50.

divides the pan into two compartments, the outer and inner compartment, and effects a thorough circulation of the pulp in the pan and its mixture with the mercury without the use of the inefficient dashboards.

2d—A quicksilver bowl is attached to the side of the pan.

3d—No muller plate or iron shoes or dies are used.

4th—The motion of the muller or rings is geared to run slowly.

If gold or a metallic silver are to be amalgated, the ring of the muller is made of copper and coated with mercury. If chlorides of silver are to be treated, a wrought-iron ring may be added. In either case the ring can easily be removed by merely lifting it out of the pan. In its use this pan differs from the combination pan—

1st—In the manner of application of mercury to the ore pulp.

2d—In the circulation of the pulp, and

3d—In the treatment of the mercury.

and plan of the Malter pan. It differs principally in four essential features from the latest improved Combination or Standard pan.

1st—The muller arms of the pan form a basket which is encircled by a copper or a wrought-iron ring. This ring

APPLICATION OF THE MERCURY TO THE ORE.

1st—The mercury is charged into the pan and remains largely at its bottom, in a contiguous body though, and over which the pre-pulp is made to pass continually.

The amalgamating ring extends to nearly the surface of the ore-pulp, and serves to catch the particles of metal in the pulp; it revolves with the muller and ore-pulp, and its amalgamating surface is constantly presented to the pulp under the most favorable conditions for the adherence of the precious metal to it. When enough amalgam has attached itself to the surface of the ring, it is removed to be scraped off and another ring is put in its place.

CIRCULATION OF THE ORE-PULP.

2d—By virtue of this arrangement of circulating the ore-pulp through and over the heated body of mercury and around the amalgamating ring, it becomes possible to treat the thinnest ore-pulp successfully, and to save the finest particles of floating metal. It is principally for the reason that the thin watery pulp can be treated in this pan that it is more suitable for the continuous-pan amalgamation process than any other pan.

One of the main difficulties commonly encountered in the continuous pan process, as ordinarily used, arises from the fact that the ore-pulp must necessarily go to the pans as it comes from the stamp battery, without previous settling, and that the great amount of water required in crushing and discharging the ore from the mortars dilutes it too much to support the particles of mercury which must be scattered through it to effect the necessary contact of metal and mercury for the purposes of amalgamation.

If the ore-pulp is not stiff enough to support the floating globules of mercury, no satisfactory result can be obtained with the combination or standard pans.

The difficulties arising from thin pulp are overcome by

the use of the Malter pan, for the reason that its positive circulation brings every particle of floating metal in, through contact with the mercury, under the most favorable conditions for amalgamation, no matter how thin the pulp.

TREATMENT OF MERCURY IN THE PAN.

3d—The use of the quicksilver bowl on the pan makes possible the inspection of the condition of the mercury, and its treatment with chemicals, at any time while the amalgamation is going on, the mercury being kept in a solid body. Thus, if it be found that during the process of amalgamation the mercury has become inactive, as it often does, the proper re-agents may be immediately applied, and to restore its most favorable condition for amalgamation. Retaining the mercury in a body in the bottom of the pan makes it possible to heat it to a higher degree than could be done if it were scattered through the pulp; besides, it has the further advantage, that it decreases the loss of mercury to a minimum. If, in the amalgamation of gold, the mercury be scattered through the ore-pulp and permitted to pass with it from the pan to the settler, it can never be collected. Each particle of mercury lost, carrying with it some gold, results in serious loss. In the amalgamation of silver, which is about twenty times less valuable than its equivalent in gold, this loss from scattered mercury and amalgam is less serious, and less pains are taken with its collection. The ordinary settler serves the purpose of collecting the scattered silver amalgam generally well enough, but with gold it is otherwise. In its treatment care must be taken from the beginning not to divide the mercury, and if divided the settler is not as efficient a machine to collect it as the continuous separators.

The separators collect all the mercury at a small discharge, while in the settler it remains more or less scattered over the entire surface of its large bottom. Moreover, the pulling of plugs in the settlers causes great loss of mercury and

amalgam, partly because of their collecting in the plug holes, but mainly because the outflow of the ore takes place some distance beneath the surface, and because the operator is apt to pull a plug too soon.

COMPARATIVE COST OF WORKING GOLD-BEARING QUARTZ IN MALTER'S CONTINUOUS PAN PROCESS AND IN THE ORDINARY GOLD MILL WITH BATTERY AMALGAMATION.

The cost of working gold ores by Malter's method of pan amalgamation is not materially larger than the cost of working them by the battery amalgamation, for the reason that the battery can be made to do more work per stamp by 50 per cent if no amalgamation is to be done in the mortar. Thus, one of our ten-stamp continuous-pan amalgamating mills will work as much ore as an ordinary fifteen-stamp gold mill with mortar amalgamation.

LABOR.

The amount of labor required in either mill per ton of ore is the same, our continuous plant being thoroughly automatic.

POWER.

No more power is required in our continuous pan mills per ton of ore than in the ordinary gold mill. The pans running slowly require but little power, which is almost entirely economized in the stamp battery; fewer stamps are required per ton of ore worked.

COST OF PLANT.

As regards the comparative cost of plant of an ordinary battery mill and one of a continuous mill, per ton of ore to be worked, the difference in the power is not great, as it is usually believed to be. In fact, it is trifling and insignificant when the advantages of better work in the continuous pan process are taken into consideration. The thorough manner in which the ore is brought into contact with the mercury in the pan expedites the amalgamation of the precious

metal, so that comparatively few pans are required. Two to four pans will suffice for a ten-stamp gold mill, and four to six for a twenty-stamp silver mill having a daily capacity of working from fifty to sixty tons of ore.

Settlers are not required for a gold mill, and may be dispensed with even in a silver mill. Tailing separators must be used in either mill.

We claim the following advantages for Malter's continuous method of pan-amalgamation over any other amalgamating process:

1st—That the mercury and precious metal to be amalgamated are brought in more thorough contact in it than in any other pan; that, thereby, the time consumed in the process is shortened and the operation cheapened, while a most thorough amalgamation of the metal is effected.

2d—That the first cost of an amalgamating mill is greatly decreased, for the reason that less motive power, fewer pans, and no settlers are required in a plant of this design than in that of any other construction to do a certain amount of work.

3d—That the loss of mercury and amalgam is greatly diminished, for the reason that owing to the amalgamating ring it is not necessary to scatter the mercury through the pulp during the operation, and that less amalgam is floured because of slower motion and decreased attrition.

4th—That the mercury can be kept in better condition to do its work during the process in this pan than in any other pan.

5th—That owing to the better circulation of the ore-pulp, fine float gold and light chlorides are less liable to escape than in any other pan-process.

THE USE OF SODIUM AMALGAM.

To use sodium amalgam effectively is one of the most difficult tasks in practical metallurgy. Gold ores which are difficult to amalgamate may be successfully amalgamated by a judicious use of sodium amalgam in the mercury. Such ores are especially tellurides of gold or gold in alloy with more or less silver, rusty gold, such as occurs in decomposed or in roasted ores, and very fine float gold. Quicksilver will not readily unite with metallic silver or gold in alloy with equal parts of metallic silver, but if one drop of sodium amalgam be added to a large body of the quicksilver, the amalgamation will take place at once. The effect of sodium amalgam upon the capacity of mercury to amalgamate with other metals is but of short duration, and addition of too much sodium amalgam at a time to a body of mercury has rather a deleterious than a beneficial effect. Hence, if a good result of the use of sodium amalgam is to be expected, it must be added in proper doses at short intervals to the mass of mercury used in the amalgamating pan. It cannot be very well used in an amalgamating pan in which the mercury is scattered through the pulp during the process of amalgamation; but it can be easily used in the Malter pan by applying it to the mercury in the bowl in drops every few minutes.

Mr. Guido Kustel constructed an apparatus for the feeding of sodium amalgam into the mercury. It consists of a hermetically closed vessel of iron, at the lowest point of which there is a small outlet, which is opened at short intervals to permit a few drops to pass out.

We are prepared to furnish this apparatus.

COATING OF COPPER PLATES.

The coating of copper plates or pan-rings with mercury for the purpose of amalgamation, may be greatly facilitated by first dissolving the mercury in pure nitric acid. The snow-like mass nitrate of mercury, which results, is then rubbed by means of a cloth, or otherwise, over the copper; a coating of metallic mercury immediately results. Plates to be coated should be first thoroughly cleaned and scoured by rubbing with a piece of brick or soft stone, and then washed with a thin solution of cyanide of potassium.

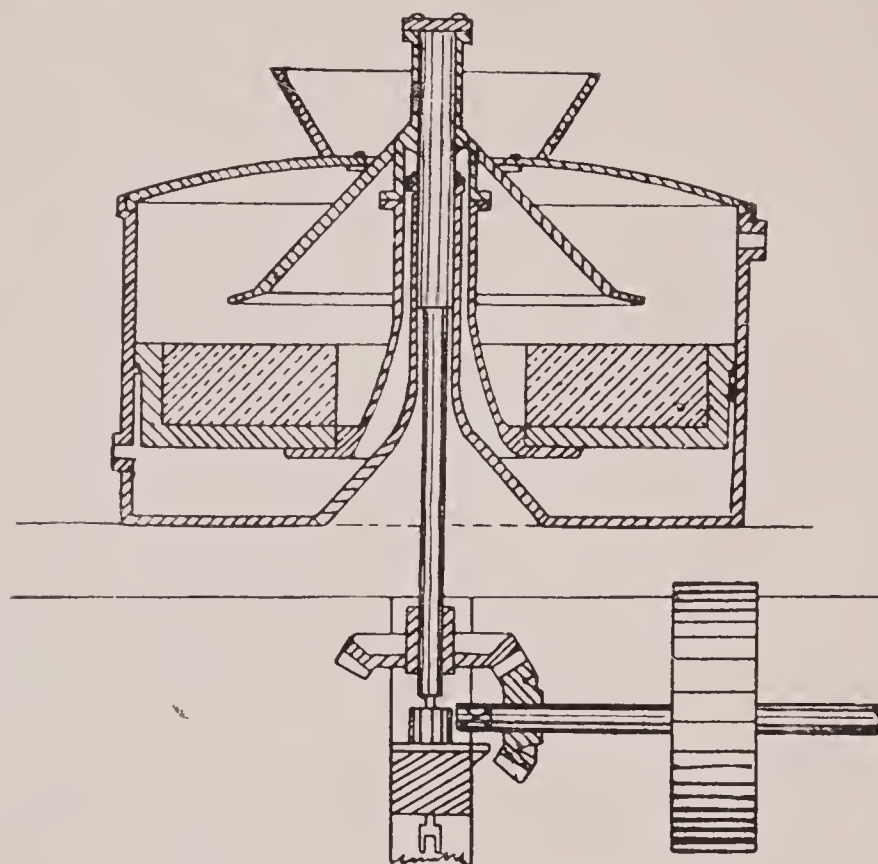
GRINDING OF ORES.

The stamp, ordinarily, is the most effective means for the reduction of brittle ores to a certain degree of fineness. Some ores, however, are not easily pulverized by the stamp to the fineness required for the extraction of the metal. Soft and clayey ore, for instance, may often be *ground* to better advantage. The amalgamating pan is not an efficient grinder, the ore does not readily go between the muller and the dies, and the same used as an amalgamator as well as a grinder will inevitably destroy part of the amalgam by flouring.

For the purpose of grinding ores and preparing them for subsequent amalgamation we use a patent iron arastra, of which the accompanying cut gives an illustration.

The arastra is constructed in form of a pan with vertical side, to the inner periphery of which is secured a ring or die, which is best made of the tires of locomotive driving-wheels.

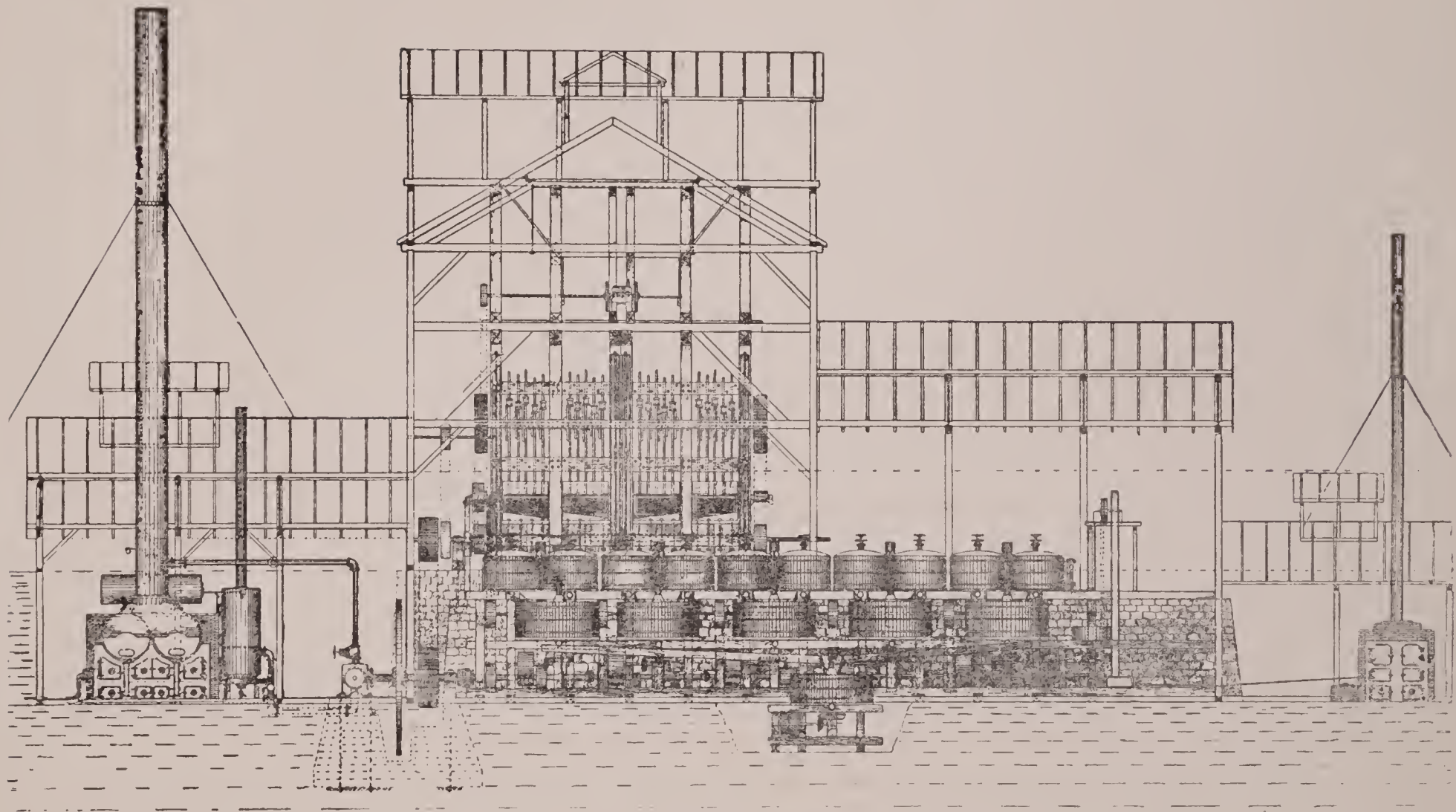
A muller plate carries the grinding blocks, which lie loosely upon it, being held in place by diaphragms cast on the muller. As the muller revolves the grinding blocks, they are pressed out by the centrifugal force against the ring or die, thereby crushing the ore which falls continuously between them as it is charged into the arastra from above.



Cut 52—Arastra for Grinding of Ores.

An inverted hopper serves to distribute the ore between the shoes and dies.

Water is introduced beneath the muller plate, and in its upward flow carries the ore with it to the discharge opening, which is placed near the upper edge of the sides of the arastra. The grinding block may be made of either iron or stone.



Cut 53—Front Elevation of Girard Mill at Tombstone, A. T.

CHLORINATION PROCESS.

The gold-bearing sulphurets, obtained by concentration from the tailing of gold mills, resist amalgamation, and are usually treated by the chlorination process.

This process consists of four distinct manipulations.

1st—Roasting of the sulphurets.

2d—Chlorinating the gold.

3d—Leaching the soluble chlorine of gold out of the insoluble mineral.

4th—Precipitation and melting.

ROASTING.

The roasting required by the gold-bearing sulphurets, which are to be treated by the chlorination process, must be a dead roasting, i.e., all the sulphurets and sulphates must be thoroughly oxidized.

If sulphates of iron remain in the roasted ore, they would precipitate the chlorinated gold in the leaching vat and make its extraction impossible. If sulphates of copper remain in the roasted ore, they might re-act upon the oxides of iron, converting them into sulphates, and cause them the same trouble.

The furnace best suited for the purpose of dead roasting of gold-bearing sulphurets is the reverberatory furnace. If the chlorination works may be conveniently located on the side of the hill, this furnace is best made in steps, that is the hearth is made in two, three or more compartments, of which the first, the one upon which the ore is charged, is the highest; and the last, the one near the fire-place where the roasted ore is discharged, is the lowest.

The ore is raked by hand continually to move it forward to the fire and to expose every particle of it to the oxidizing influence of the flame, and thus hasten the process of roasting.

The heat must be applied gradually to prevent the sulphur from igniting too suddenly, which would cause lumping of the ore; should it occur, then the lumps must be sifted from the finer ore to be re-crushed before leaching.

Especial care must be taken to keep the temperature in the furnace low if galena be present in the ores, and the stirring must be continuous to prevent the fusing of sulphides and matting.

If magnesia and lime are present in the ore it is not well suited for the chlorination process, for the reason that these minerals absorb the chlorine gas, and thereby vastly increase the expense of the process. Mr. G. F. Deetken claims to have remedied this difficulty by the addition of salt to the roasting ore shortly before its discharge from the furnace.

To ascertain whether the base metals in the ore are thoroughly oxidized, and the roasting operation finished, a sample of the ore may be taken from the furnace and put into a glass of water, then a few drops of the solution of ferrocyanide of potassium are added; if the water turn bluish or reddish or greenish the roasting must be continued until no such reaction takes place. Mechanical furnaces, such as the Bruckner, may be used, they have the advantage of economizing the labor of raking and stirring the ore, but they do not cheapen the process, for the reason that much power is consumed during the long time necessary to effect a dead roasting; beside more loss is occasioned in them by dusting than in the reverberatory.

The roasted ore is drawn from the furnace, spread on a cooling floor, and after awhile moistened either by hand or with a sprinkling apparatus.

CHLORINATION OF THE GOLD.

The moistened ore is treated with chlorine gas, and for that purpose is shoveled or dumped and sifted into wooden vats with low sides, the insides of which are coated thickly with asphaltum or tar and pitch. These vats have false

bottoms of perforated wood, over which filters of coarse quartz and fine sands are placed in layers, the coarser quartz down, the finer sands on top.

The chlorine gas is introduced through a lead pipe opening near the bottom of the vat; it rises through the ore, and when it begins to show itself upon the surface the vat is covered with a wooden cover, which is made tight by luting it around the edges with a proper kind of clay, which will not crack when drying. The ore is left under the influence of the chlorine gas for from 24 to 48 hours, until all the gold in it has been converted into soluble chlorides. The chlorine gas is generated in a leaden vessel, from proper proportions of common salt, peroxide of manganese, sulphuric acid and water, which are subjected to a slight heat.

The gas is purified before its admission to the ore tanks by passing it through water, which frees it from muriatic acid and other impurities.

LIXIVIATION.

When the ore is thoroughly chlorinated, the cover is removed from the vat and water is run over the surface of the ore continuously. Seeping through the ore it passes to the bottom of the vat and out through a pipe which conducts it to another vat, the precipitation vat. This flow of water leaches the soluble chlorine of gold from the ore. To ascertain when the operation of leaching is finished, a sample of the leaching water is taken from time to time and sulphate of iron added to it. If chlorine of gold be still present in the solution, a dark bluish precipitate will result. The leaching with water must be continued until no precipitation in the sample takes place by the addition of the sulphates of iron.

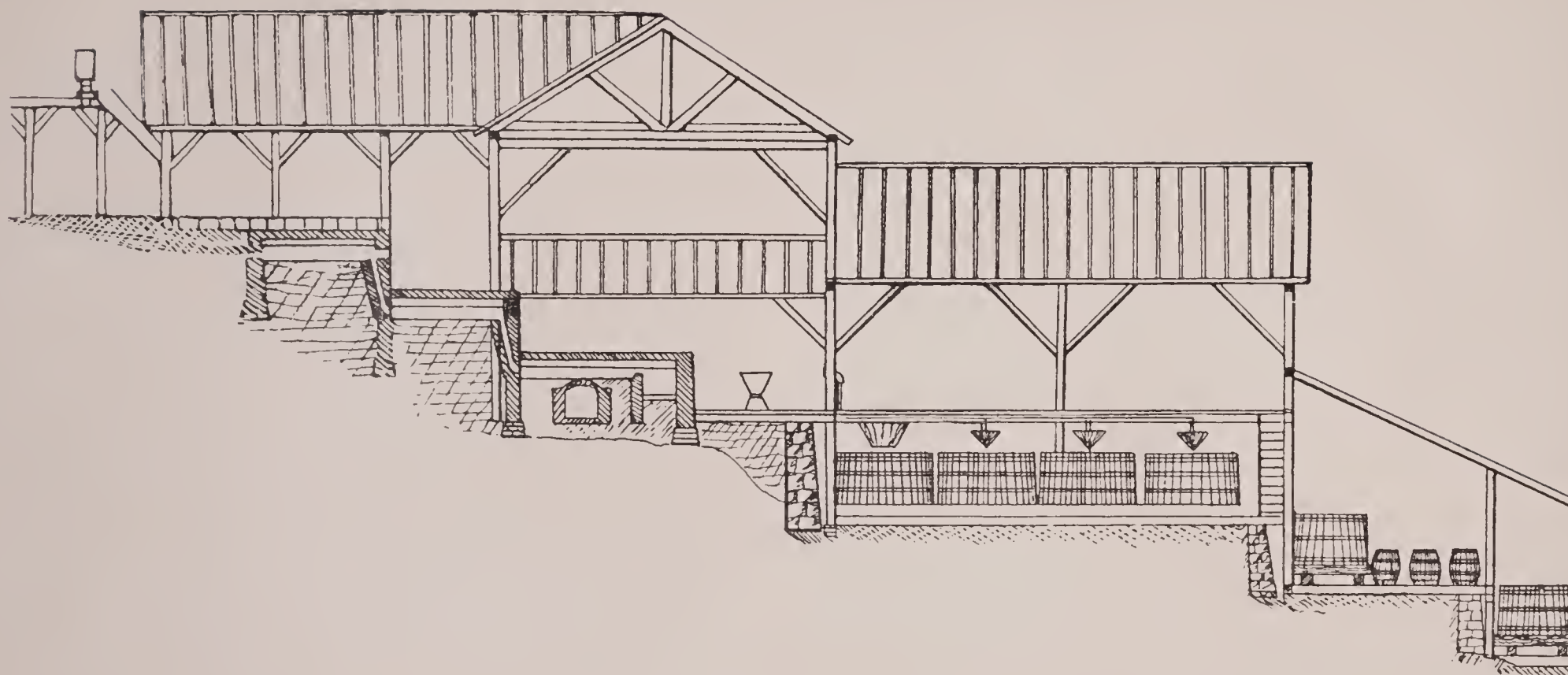
PRECIPITATION AND MELTING

A solution of sulphate of iron is used to precipitate the chlorine of gold from the liquor in the precipitation vat.

After adding this precipitant the liquor is stirred and then allowed to subside until the surface becomes clear. Then a sample of this clear liquor is taken and sulphate of iron added to it to ascertain whether all the gold has been precipitated from the solution. If the sample shows strong discoloration or some precipitation, more sulphate of iron must be added to the solution in the precipitating tank.

In order to ascertain whether a sufficient amount of sulphate of iron has been added to the liquor in the precipitation tank, a tumblerful of the clear liquor may be taken from the top of the vat, and if to it is added a little of the solution known to contain chlorine of gold, a precipitation of the gold must take place; if it does not take place, then more sulphate of iron must be added to the liquor in the precipitation vat.

After these tests show a complete precipitation of the gold, and the precipitate has settled to the bottom of the vat, which may require from one to two days, then the clear liquor is drawn off, the gold collected, filtered, and washed with dilutions of muriatic acid and warm water until all acidity is removed, when the gold is dried and melted in crucibles with borax. The base metal in it can be gotten rid of by the addition of nitric acid and skimming of the molten gold.



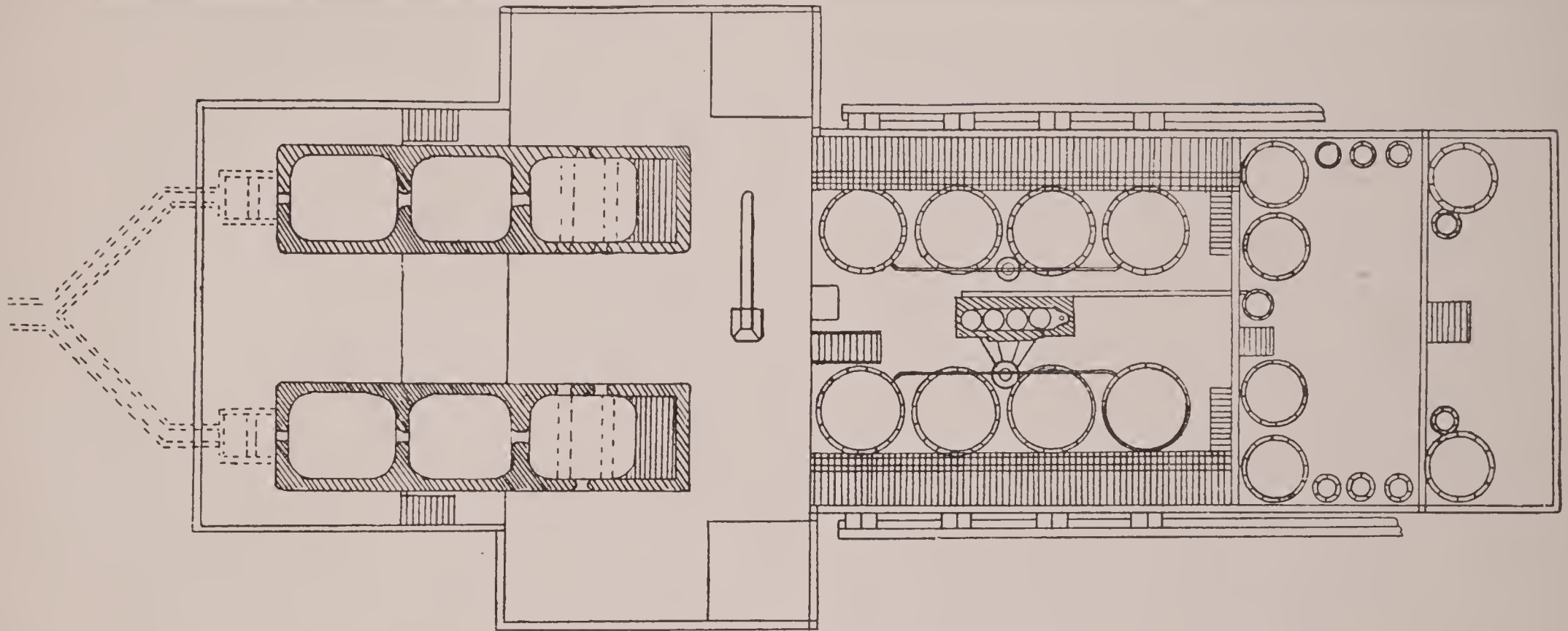
Cut 54--Chlorination Works.

CHLORINATION WORKS.

The above illustration shows the elevation of chlorination works, having a daily capacity of working 5,000 pounds of sulphurets.

The ores are first crushed by stamps, and then concentrated to separate the worthless gangue from the metals in order to prevent the too great absorption of chlorine gas,

which would largely increase the cost of the operation and might defeat the object of reduction by this process. The crushing and concentrating machinery is not shown in the above cut. After crushing and concentrating, the ores are dried by heat and brought in cars to the upper floor of a long reverberatory furnace, having three steps or floors, on different levels, as shown in the cut. In this furnace the ore is subjected to a careful dead roasting, under the influence of a gradually increasing heat.



Cut 55—Ground Plan of Chlorination Works.

The upper floor, where the ore is introduced, being the farthest from the fire-place and the lower floor, where it is discharged, being nearest the fire. The ore is continually raked by hand, and gradually moved toward the fire. A sprinkling apparatus is placed between the furnaces and the leading tanks. The chlorine gas is generated in four leaden tanks or vessels, shown in the middle of the cut, by the decomposition of oxide of manganese salt and sulphuric acid.

The gas is purified before its admission to the ore tanks, by passing through water, which frees it from muriatic acid and other impurities. The chlorination of the gold takes place in eight large vats or ore-tanks, placed on the second floor of the works, four on either side. The chlorinated gold is drained from these vats into the precipitation tubs placed beneath and immediately in front of them. The gold is precipitated by sulphurets of iron from its solution and dried and melted.

LIXIVIATION PROCESS FOR GOLD AND SILVER.

Gold-bearing sulphurets or ores, in which the gold is contained in coarse grains, cannot be worked by the chlorination process. Chlorine gas will not readily dissolve coarse gold.

If the gold ores contain much silver, it is a matter of great difficulty to extract the precious metals from them by the chlorination process. If silver very largely predominates, then the chloridization of the metal by means of roasting with salt, and subsequent amalgamation, will probably give better results. If silver does not predominate too largely or the ores are to be leached anyway, for the reason that amalgamation be not feasible, then two courses may be pursued:

1st—Salt may be added during the roasting process for the purpose of chloridizing the silver: then the roasted ore may be chlorinated to put the gold in soluble condition, when it may be extracted by water, and can then be leached out with hyposulphide of soda.

The silver solution is collected in separate vats and precipitated by the addition of sulphide of calcium, as sulphide of silver in the manner described in the leaching process for silver. The silver precipitates settle more readily than those of gold. It is filtered, washed with hot water, dried and roasted in a furnace with slowly increasing heat to drive off part of the sulphur. Then it is melted with borax and iron scraps in a black crucible, the matt and slag are skimmed off and the metal is poured.

This method has been repeatedly tried by metallurgists, but satisfactory results have not usually been obtained.

2d—The ore may be roasted without salt until all the base metals are oxidized, then it may be chlorinated and the gold leached out. The silver remains in the ore; it is dried, sulphur and salt are added, and the ore is subjected to a chloridizing roasting, which can be easily effected with little expense in a mechanical furnace.

After the silver is thus chloridized, it may be readily extracted by leaching or by amalgamation.

WEIGHTS OF MACHINERY USED IN QUARTZ MILLS

Grizzly or ore screens.....	650 to 800 lbs.
Blake crusher, 9x15....	5,400 " 12,000 "
" " 8x10 ...	4,100 " 7,000 "
Standard crusher, 8x10....	4,000 " 8,000 "
" " 9x15....	4,800 " 10,000 "
Challenge ore feeder.....	750 "
Roller " "	650 "
Stanford " "	600 "
Mortars for five 850-lb. stamps....	5,200 "
Stamp dies " " "	110 "
" shoes " " "	120 "
" stems " " "	335 "
" heads " " "	225 "
" tappets " " " 150 to	200 "
" cams, double arms... 175 to	250 "
" cam shaft 5½ diam.x14½ long	1,160 "
" Frue & Triumph concentrators	2,280 "

Grinding and amalgamating pans, 3,800 to 6,500 lbs.

Settlers..... 2,400 to 5,500 "

Clean-up pans..... 600 to 1,300 "

Retorts 1,000 to 2,600 "

Approximate shipping weight of ten-stamp gold mill, using Knight or Pelton water-wheel and two belt concentrators—28 tons.

Approximate shipping weight of twenty-stamp gold mill, having eight belt concentrators, with hurdy-gurdy water-wheel for power—59 tons.

Shipping weight of machinery for ten-stamp wet-crushing silver mill, using four pans and two settlers, clean-up pan, etc.—45 tons. Engine, boiler, etc.—70 tons.

Shipping weight of machinery for 10-stamp dry-crushing mill, 82 tons.

Power required to operate a 20-stamp wet-crushing silver mill (850-lb. stamp):

20 stamps @ $1\frac{1}{2}$ h. p. per head.....	30
12 grinding pans @ 5 h. p.....	60
6 settlers @ 3 h. p.....	18
1 9x15 crusher	6

Total h. p.....114

Gold mills require from $1\frac{1}{2}$ to 2 h. p. per stamp, and from 5 to 8 h. p. for rock-breakers. Belt concentrators require from $\frac{3}{4}$ to $1\frac{1}{2}$ h. p. for each machine.

Power for 10-stamp dry-crushing mill (850-lb. stamp):

10 stamps @ $1\frac{1}{2}$ h. p. per stamp.....	15
4 pans @ 3 h. p.....	12
2 settlers @ 2 h. p.....	4
1 48" revolving furnace.....	$2\frac{1}{2}$
1 8x10 crusher.....	5
1 dryer.....	5

Total h. p..... $44\frac{1}{2}$

Water required for stamp mill per hour in gallons:

	GALS.
Boiler for each h. p. per hour.....	$7\frac{1}{2}$
Stamps " " " "	32
Pans " " " "	120
Settlers " " " "	60

Water required for stamp mills per minute in gallons:

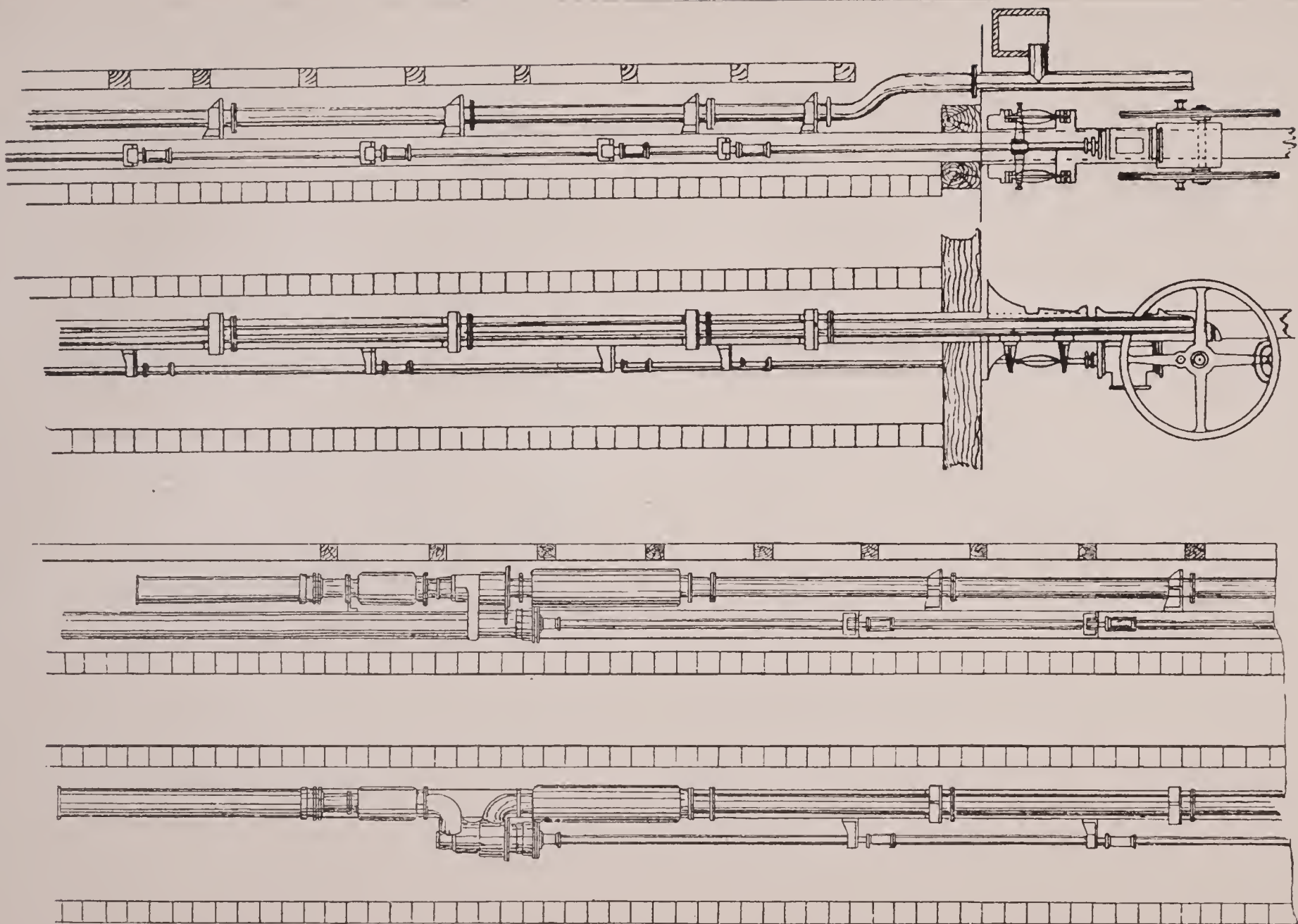
	GALS.
For 20-stamp wet-crushing mill.....	65
" 10 " " " "	32
" 10 " dry " "	15

Water required for 20-stamp wet-crushing silver mill in pounds:

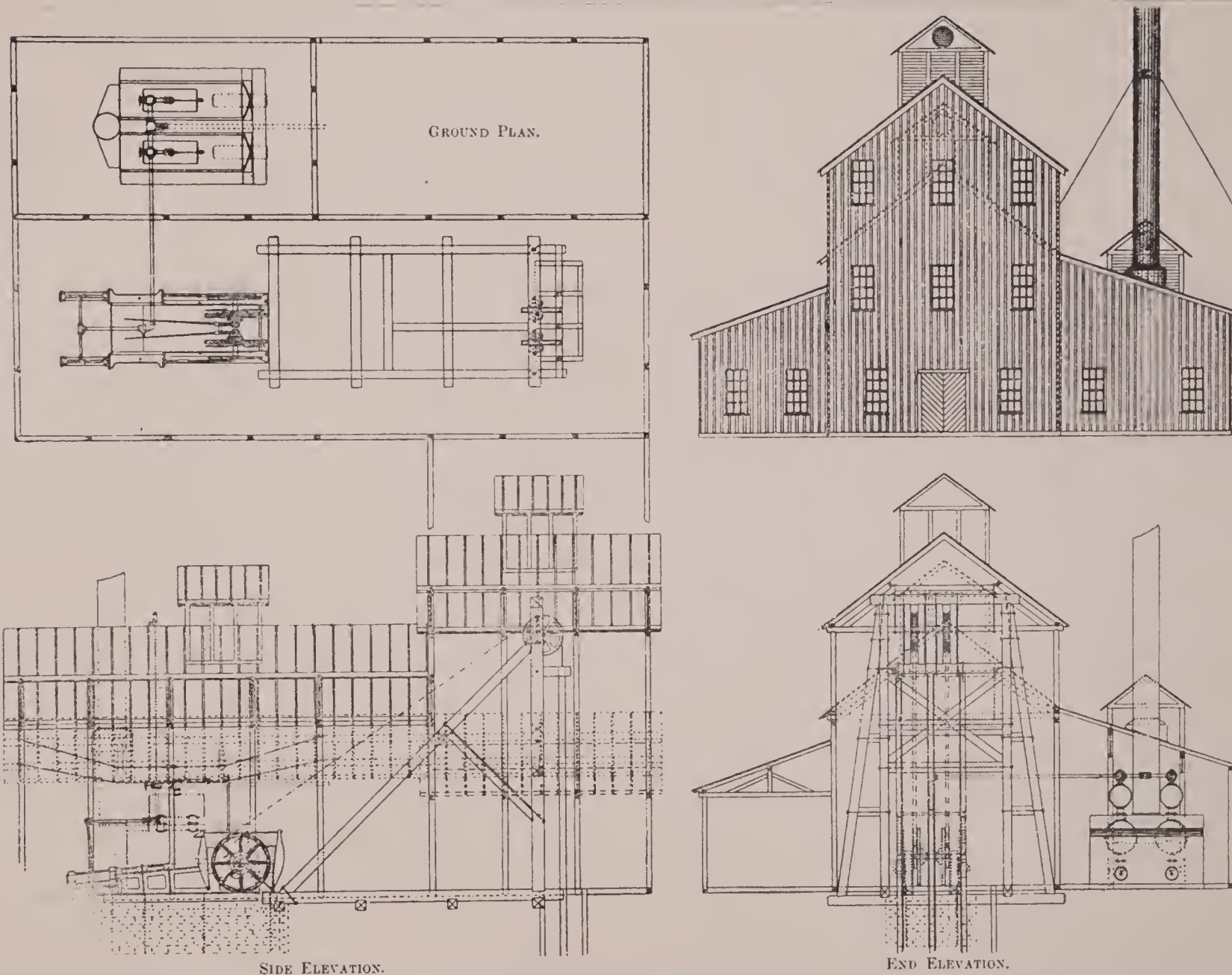
120 h. p. boiler, 20 stamps, 10 pans, 5 settlers and clean-up pan requires 568 lbs. of water per minute.

Water required for 10-stamp wet-crushing silver mill per minute, 265 lbs.

Water required for a 10-stamp dry-crushing mill 120 lbs. per minute.



Cut 56—Small Pumping Engine and Pumps, for moderate depth of shaft.



Cut 57—Hoisting Works, with Direct-acting Engines with Barclay's Cut-off, at St. Helena Mine, Mexico, built by Malter, Lind & Rogers.

Hoisting Machinery, Etc.

In this department we are prepared to furnish and erect Hoisting Works for shafts of any depth, provided with every modern improvement for hoisting cages and cars with convenience, safety and dispatch.

For deep mines the direct-acting engines are to be preferred, but for shafts ranging from 100 to 800 feet in depth the geared hoists are more generally used. We build the latter with single or double reels, for either round or flat rope, having either single or double gears of the friction, spur and curved-tooth patterns. These engines are provided with reversible links, and the reels are controlled by powerful hand and foot brakes.

The direct-acting engines are all highly finished, and usually provided with the Barelay cut-off, which is simple in construction, easy to set and manage, and very effective in

saving fuel, giving general satisfaction in use.

We also provide Hoisting Works to be run by water power, using the turbine water-wheels where low heads are only available, and the Knight, Pelton or hurdy-gurdy wheels where high heads can be secured, arranged with suitable gates controlled by governors of the most improved construction; the power is transmitted by either belts or ropes from horizontal shafts, so that no gearing is required.

We furnish improved *Safety Cages, Mining Cars, Skips, Water and Ore Buckets*, and all other appliances for use in and about mines.

We provide and erect wire-rope tramways, with every convenience for conveying ores cheaply and in large quantities from the mine to the mill.

MEASUREMENT OF LAND.

16½ feet.....	1 rod
66 feet.....	1 chain
5280 feet.....	1 mile
43,560 square feet.....	1 acre
A square the length of one side of which is	
208 feet 8½ inches, contains....	1 acre
295 " 1⅞ " " ".....	2 "
361 " 6 " " ".....	3 "
466 " 8¼ " " ".....	5 "
660 " " " ".....	10 "
933 " 4½ " " ".....	20 "
1320 " " " ".....	40 "
1866 " 9½ " " ".....	80 "
2640 " " " ".....	160 "
5280 " " " ".....	640 "

Millsites usually contain five acres.

EIGHTS AND MEASURES OF QUARTZ, SAND, ETC.

13 cubic feet of quartz in lode.....	1 ton
20 " " " " broken.....	1 "
25 " " " " sand.....	1 "
18 " " " " earth.....	1 "
17 " " " " clay.....	1 "
18 " " " " gravel before digging, 1 "	
27 " " " " after ".....	1 "

WEIGHTS OF METALS.

For cast iron, mult. cubic in. $\times .26$ = lbs. avoird.

" zinc, " " " $\times .253$ = " "	
" tin, " " " $\times .263$ = " "	
" steel, " " " $\times .282$ = " "	
" brass, " " " $\times .3$ = " "	
" copper, " " " $\times .32$ = " "	
" lead, " " " $\times .41$ = " "	

CAPACITIES OF ROUND TANKS.

Height.	Diameter.	Gallons.
6.....	8½.....	2,000
7.....	9 5-12.....	3,000
7.....	11.....	4,000
7.....	11 5-6.....	5,000
7.....	13½.....	6,000
7.....	14.....	7,000
8.....	14.....	8,000
8.....	15.....	9,000
8.....	16.....	10,000
12.....	16.....	15,000
12.....	18½.....	20,000

USEFUL DATA.

One miner's inch equals the quantity of water which will flow through an opening one inch square under a pressure or head of four inches—being about 107 lbs. per minute.

1 cubic foot of water weighs 62.3 lbs. (U. S. Standard).

1 cubic foot of water contains 7.48 gallons.

1 pound avoirdupois equals 16 ounces or 7,000 grains.

1 pound troy equals 12 ounces, or 5,760 grains.

1 gallon contains 231 cubic inches.

1 gallon of water weighs 8.33 lbs.

1 vara equals 2.75 linear feet.

1 league equals 13,750 feet or 2.6 miles.

1 square (roofing or flooring) equals 100 square feet.

1 long ton equals 2,240 pounds.

1 short ton as commonly used equals 2,000 pounds.

1 span equals 9 inches.

1 fathom equals 6 feet.

1 cable length equals 120 fathoms.

1 foot pound equals work required to raise one pound vertically one foot.

TATUM & BOWEN

34 AND 36 FREMONT STREET

SAN FRANCISCO

91 AND 93 FRONT STREET

PORTLAND, OR.

MANUFACTURERS OF

MINING AND SAWMILL MACHINERY ENGINES, ETC.

DEALERS IN

Engines, Boilers, Wood and Iron-working Machinery,
Steam Pumps, Hoisting Engines
MILL AND MINE SUPPLIES

SOLE AGENTS

Albany Lubricating Compound, Cylinder and Lubricating Oils
Shultz Patent Fulled Leather Belting and Lace Leather,
Hoe Chisel-Tooth Saws, Gardner Governors
ECONOMIC BOILERS, ETC.

STATE ASSAY OFFICE

FALKENAU & REESE
ASSAYERS

ANALYTICAL, TECHNICAL AND CONSULTING CHEMISTS

ROOM 16 SAFE DEPOSIT BUILDING

COR. MONTGOMERY AND CALIFORNIA STS., - - SAN FRANCISCO

Special attention given to receiving consignments of Ores and Base Bullion, attending to the Sampling, Assaying and Negotiating for their Sale.

ANALYSIS OF ORES, Mineral and Drinking Waters, Soils, Commercial Articles, etc. Investigations for Poison, Inspection of Mines, Mineral Springs, Metallurgical and Manufacturing Establishments promptly attended to.

Instructions given in Assaying and all branches of Chemistry.



SPECIAL NOTICE.

Contracts made to furnish and erect stamp mills for the reduction of all classes of gold and silver ores.

Concentration plants of the most improved construction, Smelting and Leaching works for silver, copper and lead ores.

Hoisting and Pumping Works for shafts of any depth. We also furnish patent steel Cornish Rolls, Rock-breakers, for coarse or fine crushing, Sizing Screens and Jigs of one, two, three, and four compartments, double or single Charge and Continuous-working Roasting Furnaces, Stamp Batteries for wet or dry crushing, Grinding Mills, patent Hydraulic Separators and Concentrators, Improved Corliss, Meyer's cut-off, High-speed and Plain Slide-valve Engines, Horizontal and Vertical Tubular Boilers, Amalgamating Pans for gold or silver ores, Settlers, Retorts, Shoes and Dies, (steel or iron) Cams, Tappets, and general mining and milling supplies of all descriptions.

Working tests made of ores to ascertain the best method of reduction.

